

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Bibliography 39-7

*Publications
of the
Jet Propulsion Laboratory
July 1965 through June 1966*

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Jet Propulsion Laboratory
July 1965 through June 1966

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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Foreword

JPL Bibliography 39-7 is a compilation of official reports of the Jet Propulsion Laboratory released July 1, 1965 through June 30, 1966. Current security classifications of all documents are indicated; however, their titles and abstracts given herein are unclassified. JPL reporting in the open literature is also included.

Jet Propulsion Laboratory reports may be requested by either entry or report number. When ordering classified documents, the government contract under which they will be used should be indicated, and requests forwarded to JPL via the cognizant contracting officer for certification of security clearance and "need-to-know." Copies of unclassified reports are available upon direct request to the Laboratory.

Contents

Technical Reports and Memorandums	1
Space Programs Summary	61
Astronautics Information Literature Search	63
JPL Reporting in the Open Literature	65
Numerical Index	77
Subject Index	79

Technical Reports and Memorandums

Technical Reports are designed to report on a single significant development, on the completion of a recognizable phase, or on the completion of an entire project, or may record data or a development growing out of an assigned project but not directly related to it.

Technical Memorandums report the results of a special study of a problem, provide preliminary information on a project, or present any other material which is intended for a limited audience.

Adams, J. B.

A01 THE UTILITY OF UNMANNED PROBES IN LUNAR SCIENTIFIC EXPLORATION

Speed, R. C., Nash, D. B., Adams, J. B.

Technical Memorandum No. 33-241, July 15, 1965

(Unclassified)

For abstract, see Entry S25.

Adams, J. L.

A02 THE JPL HIGH-IMPACT PROGRAM—1965

Adams, J. L.

Technical Report No. 32-844, February 1, 1966

(Unclassified)

This Report summarizes the progress of the JPL High-Impact Survival Program since September, 1964. During this period, impact work has increased in intensity at JPL because of such efforts as the *Voyager* landing capsule and the *Surveyor* critical data recorder. Specific efforts underway include the investigation of mechanism elements and electronic packaging techniques under impact and the development of a ruggedized gas chromatograph, an impact-resistant 3-w solid-state S-band transmitter, impact-resistant flat-plate batteries, and ruggedized antennas. The JPL development goal has remained the survival of a 10,000-*g* impact. Preimpact velocities up to 500 ft/sec are under consideration in order to cover possible Mars hard-landing situations. Test facilities have been developed in order to provide the necessary velocities. This Report presents the status of these various efforts along with experimental results where pertinent. It should be noted that this Report is concerned only with impacts in which the impact velocity is well below wave propagation velocities.

Allen, J. D.

A03 MARINER IV PHOTOGRAPHY OF MARS: INITIAL RESULTS

Allen, J. D., et al.

Technical Report No. 32-890 (Unclassified)

(Reprinted from *Science*, Vol. 149, No. 3684,

August 6, 1965, pp. 627-630)

The 22 photographs of Mars taken by *Mariner IV* have been successfully received on Earth. The Martian surface photographed is rather densely populated with impact craters whose sizes range up to at least 120 kilometers in diameter. It is inferred that the visible Martian surface is extremely old and that neither a dense atmosphere nor oceans have been present on the planet since the crater surface was formed.

Anderson, F. A.

A04 PROPERTIES AND PERFORMANCE OF THE JPL-533 PROPELLANT

Anderson, F. A.

Technical Memorandum No. 33-135, December 1, 1965

(Confidential)

This document summarizes the method of manufacturing and processing the JPL-533 propellant. It also discusses the physical, ballistic, and thermodynamic properties of this propellant.

A05 PROPERTIES AND PERFORMANCE OF THE JPL-534 PROPELLANT

Anderson, F. A.

Technical Memorandum No. 33-136, December 1, 1965

(Confidential)

This document summarizes the method of manufacturing and processing the JPL-534 propellant. It also includes a discussion of the physical, ballistic, and thermodynamic properties of this propellant.

Anderson, H. R.

A06 MARINER IV MEASUREMENTS NEAR MARS: INITIAL RESULTS

Anderson, H. R., et al.

Technical Report No. 32-833, November 30, 1965

(Unclassified)

This Report is a general discussion of *Mariner IV* and the measurements performed by the spacecraft during its flight in the vicinity of the planet Mars.

The discussion concerns itself with six aspects of the flight: (1) spacecraft description and encounter sequence; (2) the absence of Martian radiation belts and the implication thereof; (3) the search for trapped electrons and a magnetic moment at Mars; (4) zodiacal dust; (5) magnetic field measurements; (6) occultation experiment: results of the first direct measurement of Mars' atmosphere and ionosphere.

Anderson, J. D.

A07 CHARACTERISTICS AND FORMAT OF THE TRACKING DATA TO BE OBTAINED BY THE NASA DEEP SPACE INSTRUMENTATION FACILITY FOR LUNAR ORBITER

Lorell, J., Anderson, J. D., Sjogren, W. L.

Technical Memorandum No. 33-230, June 15, 1965
(Unclassified)

For abstract, see Entry L19.

Anderson, T. O.

A08 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A., Posner, E. C.

Technical Report No. 32-772, December 1, 1965
(Unclassified)

The theory and design of an advanced engineering prototype of a quantile system of data compression for space telemetry are described. The basic idea is to transmit a few *quantiles* (or percentage points, as they are sometimes called) of a histogram of experimental values formed aboard a spacecraft. Only these quantiles are transmitted to Earth, and yet a large part of the information that was contained in the original histogram can be reconstructed on Earth. Compression ratios on the order of 100 to 1 are obtainable at 100% efficiency with a simple device that performs no on-board arithmetic operations.

After summarizing the theoretical background governing the use of quantiles, what the design considerations of such a system should be are considered. Data compression ratios are computed for a typical application of the quantile system. The detailed description of the advanced engineering quantile system that has been built at Jet Propulsion Laboratory is discussed; in addition, a block diagram is given and analyzed. An important feature of the quantile system is its self-adaptive features; these are studied. Examples are given whereby quantile systems for compressing telemetry data can find application in civilian technology. Finally, experimental results using the constructed system are given.

Arms, R. J.

A09 LOCALIZED-INDUCTION CONCEPT ON A CURVED VORTEX AND MOTION OF AN ELLIPTIC VORTEX RING

Arms, R. J., Hama, F. R.

Technical Report No. 32-731 (Unclassified)

(Reprinted from *The Physics of Fluids*, Vol. 8, No. 4, April 1965, pp. 553-559)

The localized-induction concept for the induction effect of a smooth curved vortex on itself is derived. This is an approximation applicable to the limiting case of a vortex filament of infinitesimal core size and of negligible long-distance effect, and has been successfully utilized in the investigations of the motion and deformation of a curved vortex filament given various initial configurations. Two theorems obtained under this concept are that the arc length of a vortex filament and the projected area of a closed vortex filament are both invariant with respect to time. These theoretical predictions are examined by a numerical analysis of the motion of an initially plane elliptic vortex ring of various eccentricities.

Ashkenas, H.

A10 EXPERIMENTAL METHODS IN RAREFIED GAS DYNAMICS: THE STRUCTURE AND UTILIZATION OF SUPERSONIC FREE JETS IN LOW DENSITY WIND TUNNELS

Ashkenas, H., Sherman, F. S.

Technical Report No. 32-869 (Unclassified)

(Reprinted from *Rarefied Gas Dynamics*, Vol. 2, 1966, pp. 84-105)

The aim of this paper is to give a concise and easily employed guide to the results of the theory of inviscid and slightly viscous flow in the central core of a supersonic free jet; to give a résumé and confirmation of experimental results concerning the location of shock waves at high Reynolds number; to apply this information to the prediction of jet sizes and the Mach and Reynolds number ranges corresponding to various pumping systems; and to give a preliminary experimental description of the manner in which the jet flow itself undergoes transition from an inviscid-continuum flow to a free-molecular flow as the orifice Reynolds number decreases.

Aviziensis, A.

A11 A STUDY OF THE EFFECTIVENESS OF FAULT-DETECTING CODES FOR BINARY ARITHMETIC

Aviziensis, A.

Technical Report No. 32-711, May 15, 1965
(Unclassified)

The effectiveness of a class of low-cost fault-detecting codes for binary arithmetic is investigated. Causes of arithmetical errors are studied, and error magnitudes are related to logic faults and to the arithmetic algorithms of the processor. The effectiveness of the fault-detecting codes is considered for three types of logic faults. Cases of one-use and of repeated use of the faulty logic element during an algorithm are investigated separately. Fault location and the application of several check factors are developed as extensions of the fault-detecting algorithm.

Back, L. H.

B01 PREDICTION OF HEAT TRANSFER FROM LAMINAR BOUNDARY LAYERS WITH EMPHASIS ON LARGE FREE-STREAM VELOCITY GRADIENTS AND HIGHLY COOLED WALLS

Back, L. H., White, A. B.

Technical Report No. 32-728, April 1, 1965

(Unclassified)

Laminar boundary layer heat transfer and shear stress predictions from existing similarity solutions are extended to perfect gas flows, with a large free-stream velocity gradient parameter β and variable density-viscosity product $\rho\mu$ across the boundary layer resulting from a highly cooled wall. The dimensionless enthalpy gradient at the wall g'_w , to which the heat flux is related, is found not to vary appreciably with β . Thus, the application of similarity solutions on a local basis, to predict heat transfer from accelerated flows to an arbitrary surface, may be a reasonable approximation involving a minimum amount of calculation time. Unlike g'_w , the dimensionless velocity gradient at the wall f'_w , to which the shear stress is related, is strongly dependent on β .

B02 LAMINAR BOUNDARY-LAYER HEAT TRANSFER FROM A PARTIALLY-IONIZED MONATOMIC GAS BY THE SIMILARITY APPROACH

Back, L. H.

Technical Report No. 32-867, December 15, 1965

(Unclassified)

Laminar boundary-layer heat transfer from a singly-ionized monatomic gas to a highly cooled wall, with no applied external electric or magnetic fields, is analyzed by the similarity solution approach. The gas is assumed to be electrically neutral with ambipolar diffusion by ion-electron pairs. In addition, equal electron and atom-ion temperatures are assumed, and sheath effects are not considered. From existing perfect gas similarity solutions, the number of parameters that need to be investigated is reduced to those directly related to ionization effects. Solutions for the limiting cases of a large diffusion rate compared to the net production rate of ions, and for local equilibrium, are obtained for constant Prandtl number and a range of Lewis numbers. An approximation prediction method is then suggested to account for variable free-stream velocity and ionization effects in a flow over a highly cooled wall.

Barath, F. T.

B03 THE HIGH-ALTITUDE ROCKET RADAR PROJECT

Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,

Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.

Technical Memorandum No. 33-196, June 15, 1965

(Unclassified)

For abstract, see Entry B30.

Barber, T. A.

B04 SYSTEMS COMPARISON OF DIRECT AND RELAY LINK DATA RETURN MODES FOR ADVANCED PLANETARY MISSIONS

Barber, T. A., Billy, J. M., Bourke, R. D.

Technical Memorandum No. 33-228, February 15, 1966

(Unclassified)

This Report analyzes advanced planetary missions using a *Saturn IB* and simultaneous orbiting and landing spacecraft. An analysis of the relative data return capability of two alternate modes is given. One mode, the relay link, uses transmission of the lander produced data to a planetary relay communications satellite, then transmission to the Earth; the other, the direct link, uses transmission directly from the lander to the Earth. Numerical results are given for sample advanced planetary missions to Mars.

Barth, C. A.

B05 ULTRAVIOLET SPECTROSCOPY OF PLANETS

Barth, C. A.

Technical Report No. 32-822, December 1, 1965

(Unclassified)

The ultraviolet spectrum of a planet is produced by the following physical processes: (1) dayglow, the scattering of solar photons by atoms and molecules in the upper atmosphere of the planet; (2) daylight, the combination of Rayleigh scattering of solar radiation and absorption by atmospheric constituents that produces the planetary albedo in the ultraviolet; and (3) electron excitation, the excitation of atoms and molecules in the upper atmosphere by auroral electrons and by photoelectrons.

A quantitative description of each of these processes is given. The atoms and molecules that are prominent in planetary ultraviolet spectra are listed. Calculations are given of planetary molecular emission spectra that are the result of optically thin and optically thick fluorescent scattering and of excitation by auroral bombardment and by photoelectrons. Rocket measurements of the dayglow spectrum of the Earth are given for the spectral region between 2000 and 4000 Å. The main spectral features are the nitric oxide gamma bands, the ionized molecular nitrogen first negative bands, and the nitrogen second positive bands. A rocket measurement of the Earth's ultraviolet albedo between 1900 and 3200 Å is also given. This spectrum shows the absorption produced by ozone in the Earth's atmosphere.

Bastow, J. G.

B06 PROCEEDINGS OF THE MAGNETICS WORKSHOP MARCH 30-APRIL 1, 1965

Bastow, J. G.

Technical Memorandum No. 33-216, September 15, 1965

(Unclassified)

This Magnetics Workshop was concerned with the magnetic control of spacecraft. It was sponsored by the National Aero-

nautics and Space Administration and was presented at the Jet Propulsion Laboratory in Pasadena, California, from March 30 to April 1, 1965.

NASA Headquarters decided to convene this Magnetics Workshop because the need was seen to bring together the various independent groups distributed throughout the country who are concerned with the magnetic properties of spacecraft. Encouragement was offered them to discuss their particular experiences, to exchange ideas, and to provide the opportunity for other groups who are entering this field to be brought up-to-date on the state of the art. In planning this agenda, by means of a working group consisting of representatives from NASA Headquarters, JPL, and NASA's Ames and Goddard Centers, it became perfectly obvious that the topic could not be thoroughly covered in one 3-day workshop. The meetings in turn would stimulate new approaches to old problems. Therefore, it was decided not to attempt to cover the entire field at this time, but to contemplate additional workshops to be held in the future at NASA centers.

B07 MARINER-MARS SPACECRAFT MAGNETIC CONTAMINATION STATUS REPORT

Bastow, J. C.

Technical Memorandum No. 33-261, December 15, 1965
(Unclassified)

Magnetic mapping results of more than 1900 items of the *Mariner-Mars* spacecraft are tabulated in this Report.

Bauman, A. J.

B08 SOME DESIGN CONSIDERATIONS, LARGE EXPULSION BLADDERS FOR NITROGEN TETROXIDE AND HYDRAZINE

Bauman, A. J.

Technical Report No. 32-862, January 15, 1966
(Unclassified)

The problems of chemical compatibility, permeation and folding of bladders are discussed in the context of the requirements of the advanced liquid propulsion systems (ALPS). An extensive review of the literature on subjects pertinent to these problems is summarized. Several experiments are described in which bladder materials were permeated by the fuel and oxidizer, and the meaning of the results discussed. Folded paper models illustrating some attempts to find a scheme for collapsing bladders in a controlled manner are shown; none were found suitable for the ALPS application. Three appendixes review the status of knowledge concerning oxidization resistance and permeation of polymers and the nature of teflon. A lengthy bibliography and list of references are included.

Beattie, W. H.

B09 EXPERIMENTAL PROCEDURES FOR MOLECULAR WEIGHT DETERMINATION BY LIGHT SCATTERING

Beattie, W. H., Laudenslager, R. K., Moacanin, J.

Technical Memorandum No. 33-242, January 1, 1966
(Unclassified)

The experimental procedures for determining molecular weights of polymers from the angular dependence of light scattering are described in detail. A Brice-Phoenix light scattering photometer, which was modified to optimize its performance, was used to study the molecular weight of a sample of polystyrene distributed by the National Bureau of Standards. Results of the study are given.

Beaudet, R. A.

B10 MICROWAVE SPECTRUM, STRUCTURE, AND DIPOLE MOMENT OF 2, 4-DICARBAHEPTABORANE (7)

Beaudet, R. A., Poynter, R. L.

Technical Report No. 32-823 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 7, October 1965, pp. 2166-2170)

The microwave spectra of all monosubstituted carbon and boron isotopic forms, and one disubstituted boron isotopic form of 2, 4-dicarbaheptaborane (7) have been analyzed. The skeletal boron and carbon atomic coordinates determined from the rotational constants show that the molecule is a pentagonal bipyramid. The two carbon atoms lie in the pentagonal base plane and are separated by one boron atom. The two apex boron atoms appear to lie on, or very near the C axis which is perpendicular to the pentagonal base. A molecule-dipole moment of 1.32 ± 0.03 D is oriented along the planar symmetry axis.

Benedict, A. G.

B11 TABLES OF TWO-SIDED TOLERANCE FACTORS FOR NORMAL DISTRIBUTIONS

Chamberlain, R. G., Benedict, A. G.

Technical Memorandum No. 33-217, June 15, 1965
(Unclassified)

For abstract, see Entry C07.

Benson, S. W.

B12 THEORY OF THE LOW-TEMPERATURE CHROMATOGRAPHIC SEPARATION OF THE HYDROGEN ISOTOPES

King, J., Jr., Benson, S. W.

Technical Report No. 32-870 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 44, No. 3, February 1966, pp. 1007-1014)

For abstract, see Entry K12.

B13 ELECTROSTATIC INTERACTIONS IN GAS-SOLID CHROMATOGRAPHY

King, J., Jr., Benson, S. W.

Technical Report No. 32-905 (Unclassified)

(Reprinted from *Analytical Chemistry*, Vol. 38, No. 2, February 1966, pp. 261-265)

For abstract, see Entry K13.

Bentley, K. E.

B14 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES

Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the *AAS Science and Technology Series*, Vol. 2, 1964, pp. 93-117)

An important scientific objective of the unmanned exploration of the planets is the quest for life on other planets. Included in the biological experiments being developed is the analysis of planetary soil for life-related compounds. This paper describes the program in progress at the Jet Propulsion Laboratory to develop a system using a gas chromatograph and mass spectrometer in series to perform this analysis. The article explores the relative merits of this approach; also background information in areas of pyrolysis, gas chromatography miniaturization, sample enrichment devices, and mass spectrometry miniaturization is given.

B15 PYROLYSIS STUDIES. CONTROLLED THERMAL DEGRADATION OF MESOPORPHYRIN

Whitten, D. G., Bentley, K. E., Kuwada, D.
Technical Report No. 32-812 (Unclassified)
(Reprinted from the *Journal of Organic Chemistry*, Vol. 31, 1966, pp. 322-324)

For abstract, see Entry W22.

Bergens, D.

B16 PHOTON-ACTUATED MULTIPLEX SWITCH DEVELOPMENT

Bergens, D.
Technical Report No. 32-794, December 15, 1965
(Unclassified)

A photon-actuated electronic switch has been developed for multiplexing low-level analog signals. The development was done by the Components Division of the International Business Machines Corporation under contract to the Jet Propulsion Laboratory. The device represents a significant advance in this type of solid-state switching in terms of miniaturization, speed, simplicity, and potential reliability.

The switch consists of a gallium arsenide diode, as an infrared light source, and a double-emitter silicon transistor that detects the infrared photons and acts as the switch. Efficient coupling between the diode and the transistor has been achieved. Device development, theoretical considerations, problem areas, and test results are covered.

The Report is a condensation of the final IBM report, supplemented by test results and more user-oriented.

Berson, J. A.

B17 NITROGEN ANALOGS OF SESQUIFULVALENE. II. THEORETICAL CORRELATION OF GROUND-STATE PROPERTIES

Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2901-2907)

The dipole moments of a series of nitrogen anhydro bases and pyridones can be calculated by a modified Hückel technique. The agreement with experimental values is quite good. Despite pronounced bond alteration, the conjugated systems of the anhydro bases have substantial charge separation, a result that is not predicted by considerations of nmr chemical shifts. The relative acidities of the conjugate acids of these substances are not properly predicted by Hückel theory. The large spread in acidities in the series cyclopentadiene, indene, and fluorene is drastically compressed by attachment of a pyridinium nucleus. Much of the effect of annelation of the five-membered ring on the acidities of the anhydro bases of the 2-series seems to be attributable to intramolecular overcrowding in the annelated derivatives, which produces non-coplanarity of the conjugated system.

B18 NITROGEN ANALOGS OF SESQUIFULVALENE. III. THEORETICAL CORRELATION OF EXCITED-STATE PROPERTIES

Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2908-2913)

For abstract, see Entry E11.

Biber, K. W.

B19 DESCRIPTION AND ANALYSIS OF 890-MHz NOISE-MEASURING EQUIPMENT

Biber, K. W., Whittlesey, A. C.
Technical Report No. 32-898, March 31, 1966
(Unclassified)

This Report describes a narrow-band, low-noise system used with the *Ranger* spacecraft system for measuring noise at a frequency of $890.046 \text{ MHz} \pm 50 \text{ kHz}$. It includes a description of the equipment and its operation, a mathematical evaluation of system performance capabilities and of particular circuit constraints upon system operation, and a procedure for system calibration and operation.

Billy, J. M.

B20 SYSTEMS COMPARISON OF DIRECT AND RELAY LINK DATA RETURN MODES FOR ADVANCED PLANETARY MISSIONS

Barber, T. A., Billy, J. M., Bourke, R. D.
Technical Memorandum No. 33-228, February 15, 1966
(Unclassified)

For abstract, see Entry B04.

Bird, T. H.

B21 LARGE-SCALE LUNAR PHOTOGRAMMETRY

Bird, T. H.

Technical Report No. 32-918 (Unclassified)

(Reprinted from *Photogrammetric Engineering*,
March 1966, pp. 227-233)

With the advent of the *Ranger VII* pictures of the lunar surface, a new area with its challenges and problems is being opened to the photogrammetry profession. Large-scale photography and the resulting mapping tasks are bringing forth some new problems to the attention of photogrammetrists. Investigation of the lunar surface from the lunar surface is a realistic possibility. Utilization of modified terrestrial type camera systems is being considered. Accurate results for interpretation and mapping are being demanded. The problems and solutions being considered are complex and new when compared with conventional photogrammetry. Primary problems lie in areas of: (1) utilization of television presentations; (2) multi-purpose imaging systems; (3) techniques and procedures of calibration; (4) data reduction and mapping techniques for large-scale analysis. Definitive data are needed in maximizing terrestrial types of camera systems in order to obtain the best photogrammetric utilization of coming space exploration projects.

Blank, G. B.

B22 SAMPLING AND HANDLING OF DESERT SOILS

Cameron, R. E., Blank, G. B., Gensel, D. R.

Technical Report No. 32-908, April 15, 1966
(Unclassified)

For abstract, see Entry C02.

Bollman, W. E.

**B23 DESIGN PARAMETERS FOR BALLISTIC
INTERPLANETARY TRAJECTORIES.**

PART II. ONE-WAY TRANSFERS TO
MERCURY AND JUPITER

Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.

Technical Report No. 32-77, January 15, 1966
(Unclassified)

For abstract, see Entry C10.

Bourke, D. G.

**B24 THE ANALYSIS OF TIME MULTIPLEXING
SYSTEMS FOR PARTIAL SUCCESS**

Bourke, D. G.

Technical Report No. 32-698, January 15, 1965
(Unclassified)

This Report is an attempt to improve analysis methods for time multiplexing systems under partial-success criteria. Results of the analysis are in the form of probability distribution for the number of surviving measurements in a multiplexer

configuration. This form of result allows such criteria to be applied as the expected number of measurements, the expected value of the weighted measurements, or the probability that the number of surviving weighted measurements will be greater than some preassigned value.

The analysis for multiplexer configuration is based upon first modeling the basic multiplexer deck. A representative solid-state deck used by the Jet Propulsion Laboratory is used as an example. After the probability distribution of surviving measurements is obtained, its general form is used to extend the analysis to general and more complex multiplexer configurations of more than one deck. Some numerical results are presented and areas for further investigations are discussed.

Bourke, R. D.

**B25 GEOMETRIC ASPECTS OF GROUND
STATION-SATELLITE COMMUNICATIONS**

Bourke, R. D.

Technical Report No. 32-820, October 15, 1965
(Unclassified)

This Report presents a discussion of the geometric aspects of communications between a ground station and a satellite in an elliptic orbit whose line of apsides is fixed. The range to the satellite along a given vector from the ground station is shown to take on, at maximum, two values; a means for calculating these values is presented. In addition, an averaging method is used to develop an expression for the long-term fraction of time a satellite and ground station are covisible. Applications of these results to various communications satellites and ground stations are shown.

**B26 SYSTEMS COMPARISON OF DIRECT AND RELAY
LINK DATA RETURN MODES FOR ADVANCED
PLANETARY MISSIONS**

Barber, T. A., Billy, J. M., Bourke, R. D.

Technical Memorandum No. 33-228, February 15, 1966
(Unclassified)

For abstract, see Entry B04.

Brereton, R. G.

**B27 VENUS: PRELIMINARY SCIENCE OBJECTIVES
AND EXPERIMENTS FOR USE IN
ADVANCED MISSION STUDIES**

Brereton, R. G., et al.

Technical Memorandum No. 33-282, May 1, 1966
(Unclassified)

This Report reviews current knowledge about the planet Venus and describes several scientific objectives and supporting experiments for a 1500-lb *Mariner*-type spacecraft to be flown to the planet in the early 1970's. A combination of flyby and atmospheric-entry-capsule mission appears to best satisfy the scientific requirements for the mission.

Brois, S. J.

- B28 THE RELATIVE SIGNS OF THE NUCLEAR MAGNETIC RESONANCE PROTON-PROTON COUPLING CONSTANTS IN STYRENE SULFIDE AND STYRENIMINE**
Manatt, S. L., Elleman, D. D., Brois, S. J.
Technical Report No. 32-746 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2220-2225)

For abstract, see Entry M5.

Brooke, C. W., Jr.

- B29 DEVELOPMENT OF AN ELECTROCHEMICAL ENERGY SOURCE FOR THE MARINER II SPACECRAFT**
Brooke, C. W., Jr.
Technical Report No. 32-854, March 15, 1966
(Unclassified)

This Report describes in detail the development of an electrochemical energy source for the *Mariner II* spacecraft. The data presented trace the development of this battery, beginning with the definition of the electrical and mechanical requirements for the battery and concluding with the telemetered data obtained from the battery during 109 days of spaceflight to Venus. The design changes resulting from the type approval test program on the development model battery and the additional changes dictated by the *Mariner II* spacecraft system requirements were combined in the final silver-zinc battery design.

Brown, W. E., Jr.

- B30 THE HIGH-ALTITUDE ROCKET RADAR PROJECT**
Brown, W. E., Jr., Barath, F. T., Jordan, R. L., Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

This Memorandum describes the status of the High-Altitude Rocket Radar Project at the Jet Propulsion Laboratory. The purpose of the project is defined; the basic theoretical considerations are presented; and the operational systems and subsystems currently being developed, together with some of the technical problems encountered, are described.

Caltech-JPL

- C01 PROCEEDINGS OF THE CALTECH-JPL LUNAR AND PLANETARY CONFERENCE SEPTEMBER 13-18, 1965**
Caltech-JPL
Technical Memorandum No. 33-266, June 15, 1966
(Unclassified)

The conference which is described in these proceedings was jointly sponsored by the California Institute of Technology and the Jet Propulsion Laboratory as a symbol of the close scholarly relationships between the two organizations, which have been administratively linked for many years. With the

help of the National Aeronautics and Space Administration, the conference was held at the California Institute of Technology, Pasadena, California, September 13-18, 1965, and brought together more than one hundred and thirty scientists to discuss recent and current studies of the Moon, Jupiter, Venus, and Mars. Conference participants came from many centers of scientific activity in the United States, England, France, Israel, and the USSR.

Cameron, R. E.

- C02 SAMPLING AND HANDLING OF DESERT SOILS**
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report No. 32-908, April 15, 1966
(Unclassified)

Variability and characteristics of terrestrial soils and variability in methods and techniques used in sampling and handling are important factors responsible for discrepancies in results of investigations on soils. Procedures for soil sampling, as well as selection of the soil to be sampled, are usually determined by the purpose for which the soil will be used. Information is presented for the sequential selection, characterization, and sampling of a desert soil site. Procedures are recommended and illustrations given for photography of major features, sterilization of sampling equipment and sample containers, the collection of desert soils, and their handling, processing, storage, shipment, and dispersal. Aseptic technique is emphasized for the collection and handling of soil samples for microbiological studies.

Campbell, D. H.

- C03 IMMUNOADSORBENTS: PREPARATION AND USE OF CELLULOSE DERIVATIVES**
Campbell, D. H., Weliky, N.
Technical Report No. 32-900, May 1, 1966
(Unclassified)

Chemicals, biochemicals, and biological materials that combine or complex specifically with insoluble substances can be isolated from mixtures by combination with these insoluble substances followed by dissociation under conditions that do not significantly alter the properties of interest of the desired materials. Antibodies (i.e., proteins of immunity that are synthesized by animals and humans and react specifically with foreign macromolecules) can be isolated from the blood by directly linking these foreign macromolecules (antigens), or small portions of them (haptens), by chemical bonds to insoluble cellulose derivatives and using these insoluble substances (immunoabsorbents) to complex with, and remove antibodies from, the other components of blood serum or plasma. Methods are described in detail for performing these operations, and precautions are discussed for avoiding difficulties in applying these methods to different adsorbents and different antigen-antibody systems. Many antibodies can be isolated in greater than 90% yield and purity.

A brief review is given of the history of the insoluble adsorbent technique and its effectiveness and applicability for

the isolation of antibody, antigens, and the study of antigen-antibody interactions.

Carley, W. J.

C04 MARS ENTRY AND LANDING CAPSULE

Carley, W. J.

Technical Memorandum No. 33-236, February 15, 1966
(Unclassified)

The problems involved in delivering an *Apollo*-type entry capsule to Mars, entering and descending through its atmosphere, and placing a scientific payload on its surface are examined in some detail. The results indicating the feasibility and complexity of various approaches to this mission are given.

Carpenter, R.

C05 A REVIEW OF RADAR ASTRONOMY—PARTS I, II

Muhleman, D. O., Goldstein, R., Carpenter, R.

Technical Report No. 32-824 (Unclassified)

(Reprinted from *IEEE Spectrum*, Vol. 2, No. 10, October 1965, pp. 44-55 and Vol. 2, No. 11, November 1965, pp. 78-89)

For abstract, see Entry M13.

Chahine, M. T.

C06 EXACT NUMERICAL SOLUTION OF THE COMPLETE BGK EQUATION FOR STRONG SHOCK WAVES

Chahine, M. T., Narasimha, R.

Technical Report No. 32-671 (Unclassified)

(Reprinted from *Rarefied Gas Dynamics*, Vol. 1, Sec. 2, 1965, pp. 140-160)

The numerical convergence of the iterative solution to the complex BGK equation is investigated. The previous numerical techniques are vastly improved, resulting in a considerable saving in computing time and smaller errors. Consequently the number of iterations is raised above 10. New shock profiles are computed for a range of Mach numbers and a special study of the development of the complete distribution function within the shock wave is carried out.

Chamberlain, R. G.

C07 TABLES OF TWO-SIDED TOLERANCE FACTORS FOR NORMAL DISTRIBUTIONS

Chamberlain, R. G., Benedict, A. G.

Technical Memorandum No. 33-217, June 15, 1965
(Unclassified)

Comprehensive tables of two-sided tolerance factors for the normal distribution are presented. The tables presented are comprehensive and have been prepared by means of an IBM 7090 computer program.

Chaney, W. D.

C08 FINAL MARINER II TRACKING SYSTEM DATA ANALYSIS REPORT

Chaney, W. D.

Technical Report No. 32-727, September 1, 1965
(Unclassified)

The analysis of the Deep Space Instrumentation Facility spacecraft tracking performance during *Mariner II* spaceflight is summarized. Ground system configurations, and a summary of tracking histories and tracking performances during scheduled premidcourse, midcourse and postmidcourse view periods are included. The tracking data used to determine the spacecraft orbit are also summarized.

Chapman, C. P.

C09 DERIVATION OF THE MATHEMATICAL TRANSFER FUNCTION OF AN ELECTRODYNAMIC VIBRATION EXCITER

Chapman, C. P.

Technical Report No. 32-934, May 1, 1966
(Unclassified)

This Report presents a detailed solution of the mathematical equation that describes a typical electrodynamic vibration system. The mathematical analysis is compared with the empirical transfer function of a particular vibration exciter to demonstrate the validity of the equation and the value of mathematics and computers for analysis of vibration techniques.

Clarke, V. C., Jr.

C10 DESIGN PARAMETERS FOR BALLISTIC INTERPLANETARY TRAJECTORIES. PART II. ONE-WAY TRANSFERS TO MERCURY AND JUPITER

Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.

Technical Report No. 32-77, January 15, 1966
(Unclassified)

The general characteristics of ballistic interplanetary trajectories are discussed, and detailed equations are developed for the analytical model. Extensive data are presented in graphical form for trajectories to Mercury (launch dates: 1967-1968) and Jupiter (launch dates: 1968-1973). These graphs include: (1) curves of *vis viva* geocentric energy vs launch date for minimum-energy trajectories and (2) curves of 19-21 different trajectory parameters vs launch date for various *vis viva* geocentric energies. The trajectories were computed on the IBM 7090 digital computer by numerical evaluation of the analytical model, after which specific parameters of interest were automatically plotted, carefully checked, and analyzed. Procedures are outlined for use of these data by the trajectory engineer in the design and analysis of interplanetary trajectories.

C11 EARTH-MOON TRAJECTORIES, 1960-70

Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.

Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

For abstract, see Entry R12.

Clauss, R. C.

C12 A 2388-Mc TWO-CAVITY MASER FOR PLANETARY RADAR

Clauss, R. C.

Technical Report No. 32-583 (Unclassified)

(Reprinted from *Microwave Journal*, Vol. 8, May 1965, pp. 74-77)

Description of a two-cavity maser fabricated by simple and rugged construction techniques which has proved to be a useful device for radar and radio astronomy. High gain and good gain stability are achieved in a liquid-helium bath at 4.2°K. Operation at a fixed frequency with a small bandwidth requirement enables the cavity maser to compare favorably with more sophisticated amplifiers. The maser was used to receive radar echoes and measure blackbody radiation from Venus. After modifications the 35°K receiving system was used to receive radar echoes from Venus, Mars, and Mercury. The system has also been used in radiometric experiments to determine antenna parameters and radio source intensity and ellipticity. The continuous daily use of the device over a period of five months indicates the success of the cryogenic system, on which reliable field operation of a maser system depends.

Clayton, R. M.

C13 AN EXPERIMENTAL CORRELATION OF THE NONREACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE. PART VI. THE RELATION BETWEEN THE STARTING TRANSIENT AND INJECTION HYDRAULICS

Clayton, R. M., Rupe, J. H.

Technical Report No. 32-255, October 29, 1965

(Unclassified)

Starting-flow-transient criteria for gas-pressurized liquid-bipropellant rocket engines are presented. These criteria are based on a consideration of the hydraulic characteristics of the propellant-feed system, with particular emphasis on the propellant valve, the injector, and the injector-manifold volume. The desirability of a short starting transient without chamber-pressure overshoot is presumed.

A nonreactive testing technique is presented for the evaluation of the starting-flow transient prior to the commitment of an engine to its initial firing.

Results of the application of both the flow criteria and the nonreactive testing technique in an injection research program utilizing a 20,000-lb-thrust rocket motor are also presented.

C14 EXPERIMENTAL MEASUREMENTS ON A ROTATING DETONATION-LIKE WAVE OBSERVED DURING LIQUID ROCKET RESONANT COMBUSTION

Clayton, R. M., Rogero, R. S.

Technical Report No. 32-788, August 15, 1965

(Unclassified)

A single, high-amplitude pressure wave rotating with supersonic velocity about the combustion chamber axis has been observed during the resonant combustion mode of several liquid rocket research engines. The occurrence of this very steep-fronted disturbance has led to the investigation of the applicability of a rotating detonation-like wave concept to explain the phenomenon. Results of a portion of the experimental phase of the investigation are presented. The engine was operated with nitric acid and aniline/furfuryl alcohol propellants at a nominal thrust of 20,000 lb and 300 psia chamber pressure.

The observed pressure ratio across the wave front varied along the chamber wall from in excess of 20:1 near the injector to 4:1 near the nozzle entrance. The pressure ratio at the face varied from approximately 20:1 in outer half radius to less than 4:1 near the center. The nonsymmetrical wave exhibited a rise time of less than 3 μ sec at certain boundary locations.

A discussion on the performance of the high-response instrumentation system is also presented.

Cohn, G. I.

C15 ELECTROSTATIC CHARGING AND DISCHARGING MODELS AND ANALYSIS FOR RANGER SPACECRAFT DURING LAUNCH

Cohn, G. I.

Technical Report No. 32-771, August 1, 1965

(Unclassified)

Spacecraft can become charged by processes such as rocket motors exhausting electrically charged combustion products, triboelectrification, interception of drift currents, and photo and secondary emission. The charging is limited by various discharge mechanisms such as conduction via the ambient space charge, corona, and arcing. Discharges and charging may be sufficiently rapid to induce pulses of significant size in various electrical circuits within the spacecraft despite substantial amounts of shielding. These pulses may actuate a device at an inappropriate time and may even result in its destruction. A preliminary investigation of this causal chain is pursued with the aid of circuit theory and field theory.

Collins, D. J.

C16 MEASUREMENT OF THE THERMAL CONDUCTIVITY OF NOBLE GASES IN THE TEMPERATURE RANGE 1500 TO 5000 deg KELVIN

Collins, D. J., Menard, W. A.

Technical Report No. 32-903 (Unclassified)

(Reprinted from *Journal of Heat Transfer, Transactions of the ASME*, February 1966, pp. 52-56)

The thermal conductivities of argon, neon, and krypton in the temperature range 1500 to 5000 deg Kelvin have been deduced from the measurement of heat transfer rates from the

heated gases to the end wall in the reflected shock wave. Pressures ranged from approximately $\frac{1}{2}$ atm to 3 atm. The relationship between thermal conductivity and temperature was assumed to be of the form $k = aT^b$. The constant "b" was determined by a best fit to the data and the constant "a" by the known values of "k" below 1500 K. The effect of density variation in the thermal boundary layer was found to be significant in reducing the data; some previous investigations have neglected this effect.

Cooper, J. L.

C17 ADVANTAGES OF MULTIPOINT CONTROL FOR VIBRATION TESTING OF COMPLETE RANGER SPACECRAFT

Cooper, J. L.

Technical Report No. 32-847, January 1, 1965
(Unclassified)

Vibration tests performed at JPL on early *Ranger* spacecraft were made using single-point control of the input vibratory accelerations. The results of these tests clearly showed the inadequacies inherent in this method of control for large structures. Because the fixture required to attach the *Ranger* spacecraft to the shaker could not be made rigid throughout the frequency range of the test, uncontrolled inputs resulted at all the spacecraft mounting points except the point being controlled. A method for controlling each mounting point was required if realistic vibration tests were to be made. A six-channel control system was developed and put into use on *Ranger* Block III spacecraft (*Rangers VII-IX*). The control system operated in two modes: (1) automatic selection and control on the highest acceleration sensed by any one of the six control accelerometers; (2) control on the square root of the sum of the squares of the acceleration sensed by the six control accelerometers. The results obtained from single-point control demonstrate that the spacecraft input is greatly affected by control point selection. That is, an overtest or undertest will occur depending on which point is selected for control. With multipoint control, the input at each mounting point is not controlled perfectly. However, the test requirements are satisfied, and that is not possible with single-point control. Multi-point control also yields a predetermined upper bound that any one mounting point cannot exceed, thus, in effect, holding all the mounting points within a narrower band than could be realized with single-point control.

Coyle, G.

C18 MARINER IV SCIENCE PLATFORM STRUCTURE AND ACTUATOR DESIGN, DEVELOPMENT AND FLIGHT PERFORMANCE

Coyle, G.

Technical Report No. 32-832, November 15, 1965
(Unclassified)

This Report describes the *Mariner IV* scan platform and actuator and the developmental problems encountered. Equip-

ment test results and flight experience are summarized to support the discussion of design adequacy. The scan structure and actuator design are considered to be a reasonable solution within the framework of schedule, structural efficiency, interface definition, and—most important—desired functional objectives. The design techniques and problem areas described are considered to be useful data for application to future spacecraft programs.

Cuddihy, E. F.

C19 OUTGASSING RATES IN POLYMERIC FOAMS

Cuddihy, E. F., Moacanin, J.

Technical Report No. 32-840, December 15, 1965
(Unclassified)

Diffusion rates for carbon dioxide were determined on closed-cell polyurethane foams of varying densities by monitoring, for two to three weeks, the loss of weight from specimens suspended in a vacuum of 10^{-7} mm Hg. The experimental data were used to calculate diffusion coefficients for these materials, which were found to be of the order of 10^{-6} to 10^{-5} cm²/sec between 22 and 81°C.

The solution of the diffusion equation for an idealized model for a foam yielded the following expression for the diffusion coefficient:

$$D = P_c \left(\frac{RT}{M} \right) \left(\frac{\rho_0}{\rho} \right) \left[\frac{1}{(1 - \rho/\rho_0)^{1/3}} + 1 + (1 - \rho/\rho_0)^{1/3} \right]$$

which relates the diffusion coefficient D to the foam density ρ and to the permeation constant P_c , and the density ρ_0 of the bulk polymer; R is the gas constant, T the temperature, and M the molecular weight of the gas.

Using this equation and experimentally obtained values of D , a P_c of 5.1×10^{-9} (cc STP) mm/sec/cm²/cm Hg was calculated for the polyurethane material comprising the foam, which agrees within a factor of 2 for reported P_c constants for polyurethane.

Dallas, S. S.

D01 HIGH-ENERGY TRAJECTORIES FROM EARTH TO MARS AND RETURN

Dallas, S. S.

Technical Report No. 32-803, December 15, 1965
(Unclassified)

The speed increment requirements are investigated for a spacecraft traveling (1) from a circular parking orbit about the Earth, (2) to the vicinity of the planet Mars, (3) into a circular parking orbit about Mars, (4) out of the circular parking orbit about Mars (after a stay time of 7 days), (5) to the vicinity of the Earth, and (6) back into the circular parking orbit about the Earth.

A three-dimensional analytic conic approximation to the accurate integrated trajectory is used in the analysis. This ap-

proximation is similar to the one used initially in the computation of one-way interplanetary trajectories.

The characteristics of the high-energy trajectories from Earth to Mars and return for the entire decade beginning January 1970 and ending January 1980 are investigated for four round-trip flight times. The four round-trip flight times (including a 7-day stay time at Mars) are 67, 127, 247, and 487 days. The one-way flight times of the departure and return trajectories are the same. The trajectories were computed by an IBM 7090 digital computer once for each day (zero hours GMT) in the decade. The energy information that is presented for the complete decade of launch dates can be used in parametric studies of advanced manned spaceflight missions to Mars. In addition, theoretical phenomena inherent in round-trip trajectories are discussed and explained; such phenomena include the occurrence of the out-of-the-ecliptic one-way trajectory or the nearly rectilinear one-way trajectory.

Davis, J. P.

**D02 REVIEW OF INDUSTRY-PROPOSED IN-PILE
THERMIONIC SPACE REACTORS.
VOLUME I. GENERAL**

Davis, J. P., Gronroos, H., Phillips, W.

Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

This Memorandum, which is part of a three-volume survey of industry-proposed in-pile thermionic reactor concepts and potential nuclear fuels for space application, summarizes the present status of development and the problem areas associated with design. For a given fuel and at low power levels—less than 200 kwe—the externally fueled concept, by virtue of its high attainable fuel-volume fraction, results in smaller cores than the flashlight or single-diode internally fueled concepts. At higher power levels the differences are less pronounced. None of the potential nuclear fuels for thermionic reactors have yet demonstrated the burnup capability required for high-power, long-life systems.

DeMore, W. B.

D03 PRIMARY PROCESSES IN OZONE PHOTOLYSIS

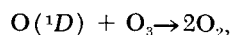
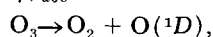
DeMore, W. B., Raper, O. F.

Technical Report No. 32-906 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*,
Vol. 44, No. 5, March 1966, pp. 1780–1783)

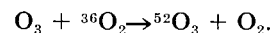
The photolysis of O_3 dissolved in liquid Ar at 87°K has been studied at 2537 Å and at wavelengths near 3130 Å. Quantum yields of O_3 photodecomposition were determined for O_3 concentrations ranging from 5×10^{-1} to 0.3 mole/liter at 2537 Å and 0.03 to 0.67 mole/liter at 3130 Å. Disappearance of O_3 is attributed to the reactions

$$\phi_{abs}$$



where ϕ is the quantum yield of $O(^1D)$ formation at a given wavelength. The limiting photodecomposition quantum yield at high O_3 concentration is about 2 at 2537 Å and about $\frac{1}{2}$ at 3130 Å.

Quantum yields were also determined at several wavelengths in the interval 2970 to 3340 Å for the photo-exchange reaction



The foregoing studies, together with previous work, show that the $O(^1D)$ quantum yield in O_3 photolysis is unity below 3000 Å but falls to a value of 0.4 ± 0.15 in the 3130-Å region. The exchange experiments show that the total quantum yield of atomic oxygen, including $O(^1D)$ and $O(^3P)$, retains a constant value of unity throughout the wavelength range studied, with onset of $O(^3P)$ formation occurring at 3000 Å.

From these results the rate of $O(^1D)$ production in the lower atmosphere is calculated to be 1.2 ± 0.5 ppm/h (pphm is parts per hundred million), based on an assumed O_3 concentration of 10 pphm and a solar zenith angle of 45°.

Devine, C. J.

**D04 THE EPHEMERIDES OF THE EARTH-MOON
BARYCENTER, VENUS, MARS, AND MERCURY
CONSIDERING THE EARTH AND MOON
AS SEPARATE BODIES**

Devine, C. J., Dunham, D. W.

Technical Memorandum No. 33-232, March 1, 1966
(Unclassified)

The differential equations for the motion of the Earth-Moon barycenter considering the Earth and Moon as separate bodies are discussed. The ephemerides of the Earth-Moon barycenter, Venus, Mars, and Mercury constructed with these differential equations are compared with the ephemerides of the same planets constructed with differential equations in which the Earth and Moon are considered as a point mass located at the barycenter of the Earth-Moon system. Position residuals and angle residuals between the two systems are plotted.

Dipprey, D. F.

**D05 ON THE EVOLUTION OF ADVANCED
PROPULSION SYSTEMS FOR SPACECRAFT**

Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.

Technical Report No. 32-735, July 15, 1965
(Unclassified)

In a current research and advanced development program, the use of Earth-storable propellants in unmanned-spacecraft propulsion systems is under investigation. The term *Earth-storable* is applied to hypergolic propellants which exist in liquid form at $70 \pm 30^\circ\text{F}$. Achievement of simplicity in propulsion-system design and operation is facilitated by the use of these propellants for flights to the near planets and the Moon. Propulsion-system requirements for such missions are

briefly outlined, and the major hazards of space flight are discussed in relation to their effect on propulsion systems.

The basic concepts of a proposed spacecraft propulsion system are presented, and component design is shown to be integrated with these concepts so that solutions to individual component problems are compatible. In the pursuit of system and component reliability, strong emphasis on simplicity and predictability is placed in opposition to the use of redundancy. The scope of this advanced development program has been delineated by three basic design choices related to the use of (1) gas-pressurized tankage for propellant pumping, (2) flexible, impermeable barriers at the liquid-vapor interface in propellant tanks, and (3) thrust chambers of refractory and ablative materials which do not require regenerative cooling. For consistent achievement of stable, efficient combustion processes, the development of procedures for a priori injector design is shown to be mandatory.

Progress is summarized in the development of an engine, a gas generator, expulsion devices, regulators, and valves, all designed to meet the requirements of spacecraft propulsion systems burning Earth-storable propellants. A methodology for a priori injector design is presented, together with its application to a simple 10-element injector of the unlike-impinging-jet configuration. Nonreactive-spray properties are used to obtain quantitative descriptions of mass and mixture-ratio distributions, and methods of obtaining the mass-distribution model for an element are outlined.

Drake, F. D.

- D06 RADIOMETRIC MAPPING OF THE MOON AT 3 MILLIMETERS WAVELENGTH**
Gary, B., Stacey, J., Drake, F. D.
Technical Report No. 32-838 (Unclassified)
(Reprinted from *The Astrophysical Journal, Supplement Series*, Vol. 12, No. 108, November 1965, pp. 239-262)

For abstract, see Entry G02.

Drummond, A. J.

- D07 EVALUATION OF THE SIMULATED SOLAR SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR**
Drummond, A. J., Hickey, J. R., Schaeffle, W. E.
Technical Report No. 32-749, August 31, 1965
(Unclassified)

Detailed results of the Eppley Laboratory, Inc., spectral investigation of the solar simulation in the JPL 25-ft space simulator during October and November, 1964, are presented. The light source consisted of 133 2.5-kw mercury-xenon compact arc lamps. Two filter radiometers, a prism monochromator, and a grating monochromator were employed. Detailed results from both techniques are presented together with the correlation philosophy and results thereof. A comparison is made with the sunlight spectrum in space, and absorptances of some surface coatings under the two light sources are tabulated.

Drummond, D.

- D08 JPL SPACECRAFT STERILIZATION TECHNOLOGY PROGRAM: A STATUS REPORT**
Drummond, D., Magistrale, V.
Technical Report No. 32-853, December 31, 1965
(Unclassified)

This document presents the technical status of Jet Propulsion Laboratory's spacecraft sterilization program, including hardware development, physical plant design and development, and sterilization technology research and development. Status reports of current tasks have been prepared by the cognizant engineers and scientists, and relevant material previously published by JPL has been abstracted.

Dunham, D. W.

- D09 THE EPHEMERIDES OF THE EARTH-MOON BARYCENTER, VENUS, MARS, AND MERCURY CONSIDERING THE EARTH AND MOON AS SEPARATE BODIES**
Devine, C. J., Dunham, D. W.
Technical Memorandum No. 33-232, March 1, 1966
(Unclassified)

For abstract, see Entry D04.

Dunne, J. A.

- D10 THE APPLICATION OF ROSS FILTERS TO THE NON-DISPERSIVE X-RAY ANALYSIS OF ALUMINUM AND SILICON**
Dunne, J. A.
Technical Report No. 32-917 (Unclassified)
(Reprinted from the *Norelco Reporter*, Vol. 13, No. 1, January-March 1966, pp. 21-24)

This paper describes the use of balanced filter pairs for the non-dispersive analysis of Al and Si in Al-Si mixtures. Less than 0.1 weight percent (wt. %) Al can be detected in a matrix of 50 wt. % Si and 50 wt. % methylcellulose. In the less favorable case of Si in an Al-rich matrix, the limit of detectability is approximately 1/2 wt. % Si in a 50 wt. % Al_2O_3 and 50 wt. % methylcellulose matrix. The filter pair for Al analysis consists of a 3 mg/cm² Al transmitting and a 5 mg/cm² Mg absorbing filter. For Si analysis, a 10 mg/cm² polystyrene-Si film and 7 mg/cm² Al foil are used for the transmitting and absorbing filters, respectively.

Easterling, M.

- E01 THE EFFECT OF THE INTERPLANETARY MEDIUM ON S-BAND TELECOMMUNICATIONS**
Easterling, M., Goldstein, R.
Technical Report No. 32-825, September 1, 1965
(Unclassified)

Consideration of the accumulated effects on microwave signals traveling through many millions of miles of space becomes important. Mechanisms have been theorized for the generation of multipath, rotation of polarization, deflection, attenuation,

and other telecommunication problems in space. There is no a priori way of assessing the magnitude of the effects of the interplanetary medium on telecommunications. Since the advent of radar astronomy, a method of measuring these influences under actual conditions has been found. The medium has been tested by sending waves through it, then analyzing the echoes reflected from the planets. The techniques used and the results obtained at S-band over a considerable area of the plane of the ecliptic are described in this paper.

Edwards, D. K.

E02 FAR-INFRARED REFLECTANCE OF SPACECRAFT COATINGS

Edwards, D. K., Hall, W. M.

Technical Report No. 32-873, January 31, 1966
(Unclassified)

Reflectances and transmittances as functions of wavelengths are reported for 17 specimens of painted aluminum and paint films. Such measurements were made with a directional integrating-sphere reflectometer in the 0.33- to 2.5- μ region, a directional heated-cavity reflectometer in the 1.5- to 23- μ region, and a far-infrared reciprocal paraboloid reflectometer in the 20- to 61- μ region. The spectral range thus includes 98% of the room-temperature emission spectrum as well as 98% of the extraterrestrial solar spectrum. Coatings of clear resins on aluminum were discovered to have high reflectances in the far-infrared when the film thicknesses were approximately 25 μ or thinner. Reflectance data for the clear-resin-coated aluminum were found to be predictable with some accuracy from the measurements of binormal transmittance of resin films together with use of the Fresnel relations. Pigmented paint resins were found to have low reflectances in the far-infrared region investigated even when the film thicknesses on aluminum substrates were as small as 25 μ .

Eisenberg, A.

E03 EQUILIBRIA BETWEEN METALLIC SODIUM AND AROMATIC HYDROCARBONS

Rembaum, A., Eisenberg, A., Haack, R.

Technical Report No. 32-765 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2291-2292)

For abstract, see Entry R08.

Eisenberger, I.

E04 TESTS OF HYPOTHESES AND ESTIMATION OF THE CORRELATION COEFFICIENT USING QUANTILES, II

Eisenberger, I.

Technical Report No. 32-755, September 15, 1965
(Unclassified)

Further results are presented in the investigation into the use of quantiles in data compression of space telemetry. Tests of hypotheses are given using one, two, and four optimum sample quantiles. In Test A, one decides whether the mean of

a normal population has a value of μ_1 or a value of μ_2 when the variance is unknown. Test \bar{D} decides whether the unknown means of two normal populations are identical when the common variance is unknown. Test \bar{E} decides whether the unknown variances of two normal populations are identical when the common mean and variance are unknown. Test \bar{F} decides whether or not two normal populations are independent when their common mean and variance are unknown. In addition, estimators of the correlation coefficient are constructed. Suboptimum test statistics and estimators using the same four quantiles are also given. In all cases, the sample sizes are assumed to be large.

E05 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A., Posner, E. C.

Technical Report No. 32-772, December 1, 1965
(Unclassified)

For abstract, see Entry A08.

Elleman, D. D.

E06 THE RELATIVE SIGNS OF THE NUCLEAR MAGNETIC RESONANCE PROTON-PROTON COUPLING CONSTANTS IN STYRENE SULFIDE AND STYRENIMINE

Manatt, S. L., Elleman, D. D., Brois, S. J.

Technical Report No. 32-746 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2220-2225)

For abstract, see Entry M05.

Estabrook, F. B.

E07 RIGID MOTIONS IN EINSTEIN SPACES

Wahlquist, H. D., Estabrook, F. B.

Technical Report No. 32-868, March 15, 1966
(Unclassified)

For abstract, see Entry W02.

Evans, D. D.

E08 ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT

Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.

Technical Report No. 32-735, July 15, 1965
(Unclassified)

For abstract, see Entry D05.

E09 DEVELOPMENT OF THE RANGER BLOCK III SPACECRAFT PROPULSION SYSTEM

Evans, D. D., Groudle, T. A., Mattson, R. F.

Technical Report No. 32-829, March 15, 1966
(Unclassified)

This Report describes the design, development, and flight operation of the midcourse propulsion system utilized on the

Ranger Block III spacecraft. This monopropellant-hydrazine-fueled system delivers 50 lb of thrust and is capable of imparting a variable impulse to the spacecraft in order to accomplish required trajectory corrections resulting from launch-vehicle dispersion errors. These corrections are required so that the time-of-arrival and impact point can be optimized in order to obtain high-resolution television pictures of the lunar surface. The propellant feed system utilizes a convenient high-pressure gas-storage system, a unique pressure regulator, and a propellant tank containing a bladder for positive expulsion. Engine ignition is accomplished through the injection of a small quantity of a hypergolic oxidizer, nitrogen tetroxide. All valving functions are accomplished by explosively actuated valves. A detailed description of component and system testing is included, along with the in-flight performance of the system during the *Ranger* VI, VII, VIII, and IX missions.

Evleth, E. M., Jr.

**E10 NITROGEN ANALOGS OF SESQUIFULVALENE.
II. THEORETICAL CORRELATION OF
GROUND-STATE PROPERTIES**

Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2901-2907)

For abstract, see Entry B17.

**E11 NITROGEN ANALOGS OF SESQUIFULVALENE.
III. THEORETICAL CORRELATION OF
EXCITED-STATE PROPERTIES**

Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2908-2913)

The experimental energies and intensities of the electronic absorption bands of a series of nitrogen analogs of sesquifulvalene are compared with the results of three kinds of theoretical treatment. Although the Hückel theory and its variant, the ω -method, are satisfactory in correlating much of the data, they fail to account for the major observed difference in behavior between the members of the 2- and 4-series, namely, the occurrence of two strong long wave length bands in the 2-series but of only one in the 4-series. Treatment of the data by first-order perturbation theory, using the series of anions phenylcyclopentadienide, phenylindenide, and phenylfluorenide, gives better results.

The transition energies are correlated with the values calculated from perturbation theory with a correlation coefficient of 0.953; the value of the resonance integral β , obtained from the slope of the correlations, is -47.6 kcal/mole.

Ewing, G. E.

**E12 INDUCED INFRARED ABSORPTION OF
SOLUTIONS OF H_2 AND D_2 IN LIQUID NEON**
Ewing, G. E., Trajmar, S.

Technical Report No. 32-764 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*,
Vol. 42, No. 11, June 1, 1965, pp. 4038-4046)

The induced infrared absorption spectra of solutions of H_2 and D_2 in liquid neon ($27.2^\circ K$) have been studied. Absorption features were found which differed by less than 7 cm^{-1} from frequencies of vibration-rotation transitions expected for the freely rotating H_2 or D_2 molecule. Rotatory energy levels of H_2 and D_2 in neon solution are, therefore, essentially the same as for gas-phase molecules. Evidence for quantized translational energy levels for the solute was found. Broad absorption features which shift in frequency with isotope change in solute are assigned to vibration-translation combination bands in which the H_2 (or D_2) molecule, in addition to increasing its vibrational level, increases its translational level in its solvent cage. The spectroscopic determination of quantized-translational energy levels permits the estimation of a solute-solvent interaction potential. A harmonic-oscillator potential to describe the intermolecular interaction is consistent with the observation that the translational energy levels for D_2 in neon are $\sqrt{2}$ smaller than those of H_2 in neon. This quadratic potential is also in order-of-magnitude agreement with the potential calculated from the Lennard-Jones and Devonshire cell model of the liquid state. The problems of quantitative determination of translational energy levels from spectroscopic data are discussed. This study has provided a spectroscopic estimate of the liquid-state interaction potential for the H_2 and D_2 neon system and an approximate evaluation of all the types of energy of the solute: vibration, rotation, and translation.

**E13 THE NEAR-ULTRAVIOLET BANDS OF MgO :
ANALYSIS OF THE $D\Delta' - A''I$ AND $C'\Sigma^- - A''I$
SYSTEMS**

Trajmar, S., Ewing, G. E.
Technical Report No. 32-770 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 142, No. 1,
July 1, 1965, pp. 77-83)

For abstract, see Entry T10.

Fedors, R. F.

**F01 THE TENSILE FAILURE ENVELOPE OF
AMORPHOUS ELASTOMERS: EFFECTS
OF STATISTICAL VARIABILITY AND
CROSSLINK DENSITY**

Landel, R. F., Fedors, R. F.
Technical Report No. 32-633 (Unclassified)
(Reprinted from the *Proceedings of the Fourth
International Congress On Rheology*, Brown University,
Providence, R.I., August 26-30, 1963. Interscience
Publishing Co., New York, 1965, pp. 543-566)

For abstract, see Entry L02.

**F02 STATISTICAL VARIABILITY OF ULTIMATE
PROPERTIES OF SBR GUM VULCANIZATES**

Fedors, R. F., Landel, R. F.
Technical Report No. 32-783 (Unclassified)

(Reprinted from *Transactions of the Society of Rheology*, Vol. 9, No. 1, 1965, pp. 195-218)

The statistical variability of ultimate properties for 8 samples of SBR-sulfur gum vulcanizates differing in crosslink density by a factor of about 25 was studied. It is shown that these variability data, determined at one rate and one temperature, can be correlated when plotted as a reduced failure envelope. The envelope obtained in this manner agrees reasonably well with the reduced envelope previously reported which was constructed from break data obtained by testing (1) single specimens of constant crosslink density at varying rate and temperature, and (2) single specimens at constant rate and temperature but varying crosslink density. It is also shown that the statistical variability data for all samples, including a benzene-soluble one, can be represented by a double exponential cumulative distribution function. It is also shown, in agreement with previous work, that the most probable values of σ_b when plotted as a function of ν_e exhibit a maximum in σ_b at a low value of ν_e .

Feitis, P. H.

F03 DESIGN PARAMETERS FOR BALLISTIC INTERPLANETARY TRAJECTORIES. PART II. ONE-WAY TRANSFERS TO MERCURY AND JUPITER

Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.
Technical Report No. 32-77, January 15, 1966
(Unclassified)

For abstract, see Entry C10.

F04 TRANSLATIONAL AND ROTATIONAL MOTION OF A BODY ENTERING THE MARS ATMOSPHERE

Feitis, P. H.

Technical Report No. 32-845 (Unclassified)
(Reprinted from *Raumfahrtforschung*, Vol. 9, No. 3, July-September 1965, pp. 124-131)
Report presented at joint annual meeting of the WGLR-DGRR (Scientific Society for Air and Space Travel, E. V., German Society for Rocketry and Space Travel, E. V.), September 16, 1965, Berlin.

The density distribution within the Martian atmosphere is derived as a function of altitude and the atmospheric parameters, assuming the perfect gas law holds. The equations of motion of simple bodies are established and solved. The solution consists of equations for the velocity, the acceleration, and time as explicit functions of altitude. The case of oblique entry into the atmosphere is also treated. It is also shown how the altitudes at which acceleration and heating are maximum can be calculated.

A sphere entering the atmosphere is studied. It is assumed that the center of gravity of the sphere does not coincide with its center. The diameter containing the sphere's center of gravity will be called its "axis." The rotational motion of the

sphere is considered, assuming that the axis of the sphere is initially inclined with respect to the trajectory. The axis carries out an oscillation in a plane, the amplitude of which decreases and then increases after maximum acceleration is reached. If in addition the sphere is spinning initially, it will carry out a complicated precessional motion around the velocity vector.

The results obtained above are compared with the exact solutions. For the exact solution, a numerical integration of the equations of motion is carried out taking into account all forces neglected above. It is seen that the new theory of motion is a considerable improvement over the old theories.

Filice, A.

F05 EVIDENCE FOR A DARKENED LUNAR SURFACE LAYER IN THE LIGHT OF RANGER VII PHOTOGRAPHS

Filice, A.

Technical Memorandum No. 33-267, October 1965
(Unclassified)

Examination of *Ranger VII* photographs indicates that the lunar maria may possess a dark, fine-grained surface layer averaging several meters in thickness. The primary observational evidence for this layer is the lower albedo of craters less than 40 m in diameter relative to craters more than 40 m in diameter in the last *Ranger VII* high-resolution photographs. The evidence implies that a crater of more than 40 m in diameter penetrates or disrupts an upper dark layer and exposes bright under-lying material. The high albedo of new rays is caused primarily by concentrations of secondary craters that penetrate darkened material.

Fischbach, D. B.

F06 KINETICS OF GRAPHITIZATION. I. THE HIGH-TEMPERATURE STRUCTURAL TRANSFORMATION IN PYROLYTIC CARBONS

Fischbach, D. B.

Technical Report No. 32-532, February 1, 1966
(Unclassified)

The kinetics of this graphitization transformation has been investigated for several pyrolytic carbons in the temperature range 2400-3000°C. The transformation was found to be thermally activated, with an effective activation energy of about 260 kcal/mole. The fundamental graphitization process appeared to be the same for all of the carbons studied. Substrate nucleated carbons deposited under the usual conditions graphitized in a succession of stages of first-order form. Variations in both the rate and the mode of transformation can be understood in terms of the dependence of the graphitization process on apparent crystallite layer diameter. A simple method of the graphitization process consistent with these observations is discussed. The significance of these observations for engineering applications is considered briefly.

F07 TENSILE AND STRUCTURAL PROPERTIES OF GLASSY CARBON

Kotlensky, W. V., Fischbach, D. B.

Technical Report No. 32-842, November 15, 1965
(Unclassified)

For abstract, see Entry K22.

Floyd, E. L.

F08 MOTOR-DRIVEN MECHANISMS FOR SPACE FLIGHT APPLICATIONS

Floyd, E. L.

Technical Report No. 32-866, February 15, 1966
(Unclassified)

A scanning mechanism was employed on the *Mariner II* spacecraft to orient the radiometer experiment. A similar device was used to orient the television camera on *Mariner IV*. These mechanisms were designed to withstand the launch-vehicle boost environment, long storage (109 days for *Mariner II* and 228 days for *Mariner IV*) in the space environment, and operation at planet encounter.

Fox, N.

F09 THE USE OF CONVENTIONAL WIND TUNNELS TO SIMULATE PLANETARY ATMOSPHERIC AERODYNAMICS

Koester, H., Fox, N.

Technical Report No. 32-762, November 15, 1965
(Unclassified)

For abstract, see Entry K19.

F10 AN EXPERIMENTAL STUDY OF THE FLOW FIELD PRODUCED BY THREE HYPERSONIC JETS IMPINGING ON A SURFACE IN A VACUUM ENVIRONMENT

Marte, J. E., Fox, N.

Technical Memorandum No. 33-231, July 30, 1965
(Unclassified)

For abstract, see Entry M13.

Frank, D. R.

F11 FACTORS AFFECTING THE REPRODUCIBILITY OF SMALL SOLID-PROPELLANT BATCH-CHECK ROCKET MOTORS FOR QUALITY-CONTROL PURPOSES

Frank, D. R.

Technical Memorandum No. 33-260, October 15, 1965
(Unclassified)

The effort expended and the initial results in evaluating a small solid-propellant batch-check motor are described. The intended use of the motor is to predict the performance of a full-size flight motor based on the measurement of a parameter *W*, relating the nozzle throat, the propellant weight and

the motor chamber pressure integral. In all cases care was taken to control the measurement of these parameters. The motor uses a replaceable graphite-throat insert that undergoes a detailed inspection before testing. The insert is used only once, and the performance calculation is based solely on the prefire measurement. To determine the motor-chamber pressure integral, three independent pressure-measurements are made. The pressure transducers are calibrated on a high-accuracy Ruska deadweight calibrator prior to use. Expected reproducibility between the pressure integral data of any channel for a given test is $\pm 0.05\%$.

Initial motor evaluation indicates that when an aluminized propellant is used the nozzle throat coating, during the early portion of the test, causes a significant change on the reproducibility of the motor. Data evaluation using aluminized propellant indicates an accuracy of $\pm 0.02\%$ for motors within a propellant batch. An accuracy of $\pm 0.10\%$ has been obtained from a non-aluminized propellant batch. At the present time the batch-check motor has not been used for its intended purpose because a correlation between the batch check and a full-size motor has not been made.

Friedman, H. L.

F12 THE HIGH-ALTITUDE ROCKET RADAR PROJECT

Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,

Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.

Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Gardner, J. A.

G01 ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE EXHAUST OF A MPD SOURCE

Kelly, A. J., Nerheim, N. M., Gardner, J. A.

Technical Report No. 32-796, September 15, 1965
(Unclassified)

For abstract, see Entry K06.

Gary, B.

G02 RADIOMETRIC MAPPING OF THE MOON AT 3 MILLIMETERS WAVELENGTH

Gary, B., Stacey, J., Drake, F. D.

Technical Report No. 32-838 (Unclassified)

(Reprinted from *The Astrophysical Journal, Supplement Series*, Vol. 12, No. 108, November 1965, pp. 239-262)

This is the first of two articles describing an observational investigation of the Moon's brightness temperature at a wavelength of 3.3 mm (frequency of 90.4 Gc/s). The study was made with the 15-foot-diameter radio telescope at the Aerospace Corporation, El Segundo, California. The antenna beam width of 2'8" enabled construction of high angular resolution maps giving contours of brightness temperature over the lunar

disk for fourteen phases of the Moon. This paper describes the techniques of observation and data reduction. A description is also given of an empirical relationship between lunar phase, location on Moon, and brightness temperature. It was found that the brightness temperature of the maria exceeds that of the neighboring highlands by $2.6 \pm 0.2^\circ$ (p.e.) K.

Gavin, T. R.

- G03 EXPERIMENTAL ASSEMBLY AND STERILIZATION LABORATORY (EASL) OPERATIONS: PHASE I**
Kapell, G. F., McDade, J. J., Gavin, T. R.
Technical Report No. 32-941, April 15, 1966
(Unclassified)

For abstract, see Entry K02.

Gayman, M.

- G04 DEVELOPMENT OF A POINT DAMPER FOR THE RANGER SOLAR PANELS**
Gayman, M.
Technical Report No. 32-793, September 1, 1965
(Unclassified)

The increase in solar panel size on *Rangers VI* through *IX* over those used on prior *Ranger* flights resulted in intolerably higher structural gains during simulated-launch vibration testing. Rather than adding more solar panel attachments as a remedy, dampers were designed to absorb some of the input energy from the spacecraft. Of the three types of dampers considered, the one selected, on the basis of probable availability within schedule, demonstrated satisfactory reduction of the dynamic gains. The damper design, geometry, and discussion of the assembly and test equipment are included in this Report. Data reduction is given in detail, and damper development results are discussed.

Gayman, W. H.

- G05 A NOTE ON BOUNDARY-CONDITION SIMULATION IN THE DYNAMIC TESTING OF SPACECRAFT STRUCTURE**
Gayman, W. H.
Technical Report No. 32-938, April 15, 1966
(Unclassified)

A common practice of subjecting an entire spacecraft to a sine-sweep environmental vibration test is examined in the light of the actual boundary conditions prevailing at the interface of the spacecraft and its launch vehicle. By recourse to some simple experiments, it is shown that the conventional sine-sweep test is not only inappropriate as a structural test, but also may provide either an overly severe or an unconservative test of certain subassemblies or assemblies. Recommendations are made for fuller utilization of dynamic-response analyses that treat the flexible spacecraft as an integral part of the flexible space vehicle system. It is concluded that such analyses can aid the acquisition and interpretation of struc-

tural flight test data and, also, establish the nature of the required structural qualification testing.

Geller, M.

- G06 MANY-ELECTRON-THEORY AB INITIO CALCULATION FOR THE Be ATOM**
Geller, M., Taylor, H. S., Levine, H. B.
Technical Report No. 32-799 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 5, September 1965, pp. 1727-1736)

The details and results of an *ab initio* calculation of the energy of the Be atom using the Sinanoglu many-electron theory are presented. Comparisons are made with earlier calculations on the Be atom by this technique and by other techniques. Finally, the pitfalls and shortcomings of the many-electron theory on extension to larger systems are discussed.

Gensel, D. R.

- G07 SAMPLING AND HANDLING OF DESERT SOILS**
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report No. 32-908, April 15, 1966
(Unclassified)

For abstract, see Entry C02.

Giffin, C. E.

- G08 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES**
Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the *AAS Science and Technology Series*, Vol. 2, 1964, pp. 93-117)

For abstract, see Entry B14.

Gin, W.

- G09 HEAT STERILIZATION OF PYROTECHNICS AND ON-BOARD PROPULSION SYSTEMS**
Gin, W.
Technical Memorandum No. 33-263, January 10, 1966
(Unclassified)

Chemical-propellant rockets, both liquid and solid, for primary propulsion and possibly for auxiliary power supply, and electroexplosive subsystems are being investigated at JPL in order to arrive at engineering design criteria and constraints applicable to these equipments when incorporated into heat-sterilized spacecraft. General problems, presently applied developmental solutions, and future work are described.

Progress is reported on the development of a general-purpose, hot-bridge-wire squib initiator.

The technology required for a sealed, liquid-propellant supply system which withstands sterilization temperatures is

being developed. The principal conclusions of an analysis of the general relationships among the thermodynamic and spatial variables of a closed system are presented. Exploratory tests have been performed on the power switching and pyrotechnic control circuitry used in the *Mariner-Mars* and *Ranger* Block III spacecraft. Test results show no evidence of serious degradation of the electrical components and functions.

Progress has been made in the determination of the ability of current solid propellants to withstand the sterilization temperature cycling. Possible methods of achieving substantial decontamination prior to terminal heat sterilization are described. Design considerations for configurations that may yield minimum-stress propellant grains are discussed and exploratory test results are shown.

The conclusion is reached that the requirement for dry-heat sterilization at temperatures up to 145°C for three 36-hr cycles imposes no fundamental obstacles for pyrotechnic, liquid-propellant, or solid-propellant subsystems.

Goldstein, R.

- G10 A REVIEW OF RADAR ASTRONOMY—PARTS I, II**
Muhleman, D. O., Goldstein, R., Carpenter, R.
Technical Report No. 32-824 (Unclassified)
(Reprinted from *IEEE Spectrum*, Vol. 2, No. 10,
October 1965, pp. 44–55 and Vol. 2, No. 11,
November 1965, pp. 78–89)

For abstract, see Entry M31.

- G11 THE EFFECT OF THE INTERPLANETARY MEDIUM
ON S-BAND TELECOMMUNICATIONS**
Easterling, M., Goldstein, R.
Technical Report No. 32-825, September 1, 1965
(Unclassified)

For abstract, see Entry E01.

Goranson, G. G.

- G12 COMMENTS ON THE OPERATION OF THE JPL
25-ft SPACE SIMULATOR**
Goranson, G. G.
Technical Report No. 32-885, January 25, 1965
(Unclassified)

The Jet Propulsion Laboratory's 25-ft space simulator has been used continuously during 1963 and 1964 for tests of *Ranger*, *Mariner* and *Surveyor* spacecraft. Comments are made concerning the importance of combined solar and space simulation to the JPL flight projects. Problems, which are peculiar to the operation of a large space simulator, are discussed relative to operating experience at JPL.

Gray, L. D.

- G13 SPECTRAL EMISSIVITY CALCULATIONS FOR
THE PARALLEL BANDS OF CARBON
DIOXIDE AT 4.3 MICRONS**
Gray, L. D.

Technical Report No. 32-754 (Unclassified)
(Reprinted from the *Journal of Quantitative Spectroscopy
and Radiative Transfer*, Vol. 5, 1965, pp. 569–583)

The quasi-statistical band model is used to compute spectral emissivities for homogeneous paths of CO₂. Emissivities are presented for temperatures from 150 to 600°K, covering the temperature range encountered in planetary atmospheres where carbon dioxide adsorption is expected to be significant. These emissivities can be used to calculate atmospheric transmission.

The present results are compared with both experimental measurements and other theoretical calculations. Spectrally, the agreement with observed values of absorption is seen to be somewhat better than in previous calculations.

- G14 SPECIAL ABSORPTION OF THE 4.6-μ
BANDS OF N₂O**

Gray, L. D.

Technical Report No. 32-792 (Unclassified)
(Reprinted from *Applied Optics*, Vol. 4, No. 11,
November 1965, pp. 1494–1499)

The spectral absorption due to parallel bands of nitrous oxide is computed in the region of the ν_3 fundamental for temperatures of 200 and 300°K. The harmonic-oscillator approximation was used to compute the relative intensities of vibrational transitions for which no published data are available. The total integrated intensity of all of the transitions considered in the calculation was normalized to a value of 1850 cm⁻² atm⁻¹ at 300°K. Values of the spectral absorption computed using the quasi-statistical band model and a half-width of 0.05 cm⁻¹ at 300°K are compared with published experimental data for various amounts of absorbing gas and total pressures; the results are seen to be in good agreement. A comparison of the spectral absorption obtained using the quasi-statistical band model and the strong-line and weak-line approximations is also given.

- G15 RELATIVE INTENSITY CALCULATIONS FOR
CARBON DIOXIDE**

Gray, L. D., Selvidge, J. E.

Technical Report No. 32-817, (Unclassified)
(Reprinted from the *Journal of Quantitative Spectroscopy
and Radiative Transfer*, Vol. 5, No. 2, March–April 1965,
pp. 291–301)

Internal and vibrational partition functions of ¹²C¹⁶O₂ are tabulated for the temperature range 150–1200°K at 10°K intervals. Rotational line intensities, relative to the total intensity of the band at 300°K, are presented for transitions arising from the state 00°0 and from the state 01°0.

Gronroos, H.

- G16 REVIEW OF INDUSTRY-PROPOSED IN-PILE
THERMIONIC SPACE REACTORS.
VOLUME I. GENERAL**
Davis, J. P., Gronroos, H., Phillips, W.

Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

For abstract, see Entry D02.

Groudle, T. A.

G17 DEVELOPMENT OF THE RANGER BLOCK III SPACECRAFT PROPULSION SYSTEM

Evans, D. D., Groudle, T. A., Mattson, R. F.
Technical Report No. 32-829, March 15, 1966
(Unclassified)

For abstract, see Entry E09.

G18 DEVELOPMENT OF THE POST-INJECTION PROPULSION SYSTEM FOR THE MARINER-C SPACECRAFT

Schmitz, B. W., Groudle, T. A., Kelly, J. H.
Technical Report No. 32-830, April 1, 1966
(Unclassified)

For abstract, see Entry S05.

Gutierrez, R.

G19 THE HIGH-ALTITUDE ROCKET RADAR PROJECT

Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Haack, R.

H01 EQUILIBRIA BETWEEN METALLIC SODIUM AND AROMATIC HYDROCARBONS

Rembaum, A., Eisenberg, A., Haack, R.
Technical Report No. 32-765 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2291-2292)

For abstract, see Entry R08.

Hall, M., Jr.

H02 HADAMARD MATRICES OF ORDER 20

Hall, M., Jr.
Technical Report No. 32-761, November 1, 1965
(Unclassified)

Report studies Hadamard matrices of order 20. Proof is given that there are exactly three classes of such matrices; the work done to show this result is discussed, and the classes are found explicitly. *Class* refers to permutation of rows and columns, and changing the sign of entire rows and columns.

Hall, W. M.

H03 FAR-INFRARED REFLECTANCE OF SPACECRAFT COATINGS

Edwards, D. K., Hall, W. M.

Technical Report No. 32-873, January 31, 1966
(Unclassified)

For abstract, see Entry E02.

Hama, F. R.

H04 LOCALIZED-INDUCTION CONCEPT ON A CURVED VORTEX AND MOTION OF AN ELLIPTIC VORTEX RING

Arms, R. J., Hama, F. R.
Technical Report No. 32-731 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 4, April 1965, pp. 553-559)

For abstract, see Entry A09.

H05 ESTIMATION OF THE STRENGTH OF LIP SHOCK

Hama, F. R.
Technical Report No. 32-874 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 4, No. 1, January 1966)

There is a common assumption that the strength of the lip shock is quite weak both in theories dealing with the base-pressure problem and in experiments. An experimental result obtained by Hastings shows that the increase in the static pressure across the lip shock is only a few percent and thus supports the assumption.

During an experimental investigation of the base-pressure problem currently being conducted in the Jet Propulsion Laboratory's 20-in. supersonic wind tunnel, a distinct slip stream was consistently observed behind the junction between the lip shock and the compression shock. An attempt therefore was made to estimate the strength of the lip shock from its orientation.

Harding, J. T.

H06 FORCE ON A SUPERCONDUCTING SPHERE IN A MAGNETIC FIELD: THE GENERAL CASE

Harding, J. T.
Technical Report No. 32-806, September 1, 1965
(Unclassified)

Because a superconductor is diamagnetic, it experiences a force when immersed in a nonuniform magnetic field. This Report gives the result of the calculation of the force acting on a sphere of zero permeability in an arbitrary magnetic field. The solution is obtained by expressing the applied field in a series of complete spherical harmonic functions, determining the induced field required to satisfy the boundary condition $B_{normal} = 0$, then integrating the Maxwell stress tensor over the sphere's surface. The final result appears as sums of products of the expansion coefficients of the applied field. To make the result more useful, it is also shown how to express the field due to an array of coils having concurrent axes in a series of spherical harmonics and, for the purpose of computing restoring forces, the applied field is expanded in a Taylor series expansion in the displacements.

Hardy, J. P.

- H07 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS**
Ingham, J. D., Lawson, D. D., Manatt, S. L., Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75-91)

For abstract, see Entry I03.

Harrison, R. G., Jr.

- H08 A PRESSURE TELEMETER FOR WIND-TUNNEL FREE-FLIGHT PRESSURE MEASUREMENT**
Harrison, R. G., Jr.
Technical Report No. 32-763, February 1, 1966
(Unclassified)

This Report summarizes the work on a pressure telemeter—the instrument itself, and the applicable telemetry technique—developed for use in studying interference-free pressures on models launched into free flight in a hypersonic, continuous-flow wind tunnel. Design characteristics, performance and operational procedures, as well as problems that were delineated during the development phase, are described.

Havlik, A. J.

- H09 END-GROUP MODIFICATION OF POLY(ALKYLENE OXIDES). VOLUME I. CYANOETHYLATION**
Kalfayan, S. H., Havlik, A. J.
Technical Memorandum No. 33-251, December 15, 1965
(Unclassified)

For abstract, see Entry K01.

Hayes, C. D.

- H10 POWER SPECTRAL DENSITY ANALYSIS**
Hayes, C. D.
Technical Report No. 32-928, June 15, 1966
(Unclassified)

This Technical Report develops the generalized techniques for determining the equation describing the power spectral density function (G^2/cps versus frequency, etc.) and the equation for determining the root mean square of a power spectral density function. Examples of both types of equations are included in the Appendix.

Hays, L. G.

- H11 TURBINE EROSION RESEARCH IN GREAT BRITAIN**
Hays, L. G.
Technical Memorandum No. 33-271, March 1, 1966
(Unclassified)

The variables influencing erosion in wet-vapor turbines are identified and discussed in this Memorandum. Information is

presented that was obtained from a visit to research installations in Great Britain during October of 1965. The applicability of this information to the formulation of an analytical model of erosion in liquid-metal vapor turbines is indicated. Phenomena for which results are given are moisture formation, moisture collection, droplet shedding, droplet breakup, liquid impact, and material removal. Analytical expressions are indicated for moisture formation, moisture collection, droplet breakup, and liquid impact. Experimental results for droplet shedding and material removal are summarized. The sizable scatter of experimental data from material removal experiments and the lack of sufficiently accurate liquid-metal property data will limit the accuracy of the analytical model to be formulated.

Heacock, R. L.

- H12 RANGER VIII AND IX. PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS**
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

This Report presents the preliminary results of the analyses of the *Ranger VIII* and *IX* lunar photographs by the team of experimenters appointed by the National Aeronautics and Space Administration, with emphasis on the qualitative interpretations of the photographs. The longer-term quantitative study of the *Ranger VII* photographs is underway, and the *Ranger VIII* and *IX* mission photographs are being added to that effort.

Hendel, F. J.

- H13 REVIEW OF SOLID PROPELLANTS FOR SPACE EXPLORATION**
Hendel, F. J.
Technical Memorandum No. 33-254, October 1, 1965
(Unclassified)

Various families of solid propellants which are or could be used in space vehicles and spacecraft are reviewed. These include polyurethane, polybutadiene-acrylic acid, polybutadiene-acrylic acidacrylonitrile, carboxyl-terminated polybutadiene, double base, and thermoplastic polymers as fuel and binders of the crystalline oxidizers with or without aluminum or beryllium powder. Future solid propellants will have improved physical properties and specific impulse. Improved specific impulse will result from the use of energetic oxidizers, such as lithium ozonide, energetic fuel-binders such as nitropolymers and acetylenic polymers, and energetic fuel ingredients such as light metal hydrides. An ultra-energetic cryogenic solid propellant could be made by freezing a mixture of liquid oxygen and hydrogen or a light metal hydride. A "cold" solid propellant made from BeH_2 and frozen hydrogen peroxide will have a theoretical vacuum specific impulse of almost 500 sec.

Hess, H. H.

**H14 LUNAR AND PLANETARY X-RAY
DIFFRACTION PROGRAM**

Hess, H. H., Speed, R. C.

Technical Memorandum No. 33-218 (Progress Report
of Research and Instrumentation Development July 1964
to March 1965), June 1, 1965 (Unclassified)

Three areas of study are covered: (1) current instrumentation, (2) advanced instrumentation, and (3) X-ray mineralogy and petrology. Included are: (1) a description of the new power supply and electronic systems for Mark 1 diffractometer, (2) operating characteristics of beryllium-window sample cup and the Mark 1 X-ray tube, (3) a comparison of the Seemann-Bohlin and Bragg-Brentano diffractometer designs, (4) discussion of feasibility studies of radioisotope X-ray sources and non-dispersive X-ray fluorescence instrumentation, and (5) the relationship of the aspects of quantitative rock analysis by X-ray diffraction, the results of studies of rock-forming oxide phases and the effects of radiation damage on X-ray diffraction analysis of rock.

Hickey, J. R.

**H15 EVALUATION OF THE SIMULATED SOLAR
SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR**

Drummond, A. J., Hickey, J. R., Schaeffe, W. E.

Technical Report No. 32-749, August 31, 1965
(Unclassified)

For abstract, see Entry D07.

Higa, W. H.

**H16 A PRACTICAL PHILIPS CYCLE FOR
LOW-TEMPERATURE REFRIGERATION**

Higa, W. H.

Technical Report No. 32-712 (Unclassified)
(Reprinted from *Cryogenic Technology*, Vol. 1, No. 5,
July-August 1965, pp. 203-208)

The machine described combines the simplicity and efficiency of the Philips cycle with the versatility of the related Gifford-McMahon cycle. The new approach is particularly applicable to small low-temperature refrigerators.

A thermodynamic analysis of the cycle, assuming isothermal processes, demonstrates that the coefficient of performance is equal to that of the ideal Carnot cycle.

Higgins, M. D.

**H17 THE SPACE FLIGHT OPERATIONS FACILITY
DOCUMENT CONTROL DATA STORAGE AND
RETRIEVAL SYSTEM**

Higgins, M. D., Lunine, L. R.

Technical Memorandum No. 32-288, June 15, 1966
(Unclassified)

The Memorandum explains the data storage and retrieval techniques used at the JPL Space Flight Operations Facility Document Control to handle great volumes of flight and test

data. The various types and forms of data received at the Facility are defined and illustrated. Each item of data is indexed, and, depending upon the type of data, stored in original form or on microfilm. A computer-generated catalog is used to locate material on either microfilm, or original magnetic or teletype tapes. The Memorandum contains a complete discussion of the work flow through the data storage system, and concludes with information concerning the efficiency of the retrieval system.

Hilderbrandt, A. F.

**H18 SUPERCONDUCTING TRANSITION OF A
ROTATING SUPERCONDUCTOR—
THE HOLLOW CYLINDER**

Hilderbrandt, A. F., Saffren, M. M.

Technical Report No. 32-710 (Unclassified)

(Reprinted from *Low Temperature Physics-LT9 (Part A)*,
Plenum Press, 1965, pp. 459-465)

A superconductor, when rotated, is expected to generate a magnetic field. Hollow superconducting cylinders of lead and of niobium, when rotated starting from rest, have been found to generate fields in agreement in sign and magnitude with the relation

$$\mathbf{B} = - \frac{2mc}{e} \boldsymbol{\omega} = 1.137 \times 10^{-7} \boldsymbol{\omega} [\text{G}]$$

where m and e ($e = -|e|$) refer to the electron. Note that \mathbf{B} and $\boldsymbol{\omega}$ point in the same direction, a feature that was carefully verified. The field generated by rotation of a solid cylinder of lead, made superconducting while at rest, also followed the above equation.

Here hollow-cylinder experiments are reported, in which the superconducting transition takes place while the cylinders are rotating.

The fields observed in both the present and previous experiments are accounted for in terms of the values of the fluxoid associated with a hollow cylinder. This is done by solving London's equation for the field of a rotating hollow cylinder of infinite length, taking care to make the dependence of the field on the fluxoid explicit. The value assigned the fluxoid cannot be determined from the solution but must be given by a separate argument. The values of the fluxoid predicted by this argument lead to the most stable state, thermodynamically, of the superconductor.

Results are summarized in an expression for the field \mathbf{B} observed in the hollow portion of a long superconducting cylinder whose thickness and inner radius are both very large compared to a penetration depth. The expression is

$$\frac{e\mathbf{B}}{2mc} = - (\boldsymbol{\omega} - \boldsymbol{\omega}'_0)$$

where $|e|\mathbf{B}/(4\pi mc)$ is the Larmor frequency of the electron, $\boldsymbol{\omega}$ is the angular velocity of the cylinder, and $\boldsymbol{\omega}'_0$ is a quantity determined at the time the cylinder became superconducting;

ω_0' is equal to $\omega_0' + (e/2mc)\mathbf{B}_\infty$, where ω_0 and \mathbf{B}_∞ are the values of angular velocity and uniform field applied at the time of the transition.

Hoffman, A. R.

H19 PYROTECHNIC SHOCK ANALYSIS AND TESTING METHODS

Hoffman, A. R., Randolph, J. E.

Technical Memorandum No. 33-270, February 15, 1966
(Unclassified)

This Report presents a detailed analysis of certain pyrotechnic shocks. The data used are from the *Ranger* Block III and *Mariner-Mars* 1964 test programs. Shock spectra from the basis of correlation between similar shocks of various spacecraft and assembly testing. Comparisons of shock data using statistical methods are also included. Since a wealth of shock data was available, the statistical analysis is significant.

The results indicate the necessity for a system-level pyrotechnic test program if the environment is to be properly simulated.

Holdridge, D. B.

H20 LEAST SQUARE FIT TO PLOD RECTANGULAR RESIDUALS

Holdridge, D. B.

Technical Memorandum No. 33-244, October 1, 1965
(Unclassified)

A least squares fit to the Planetary Orbit Determination Program (PLOD) rectangular residuals for the outer planets Jupiter, Saturn, and Uranus was undertaken. A linear combination of a cubic equation in time and sinusoidal terms in the mean anomaly of the Earth and of Mars was used in the fit. For all the planets considered, the amplitude of the Earth and of Mars terms was less than that considered by Clemence in his corrections to the outer planets.

Hunter, J. A.

H21 MARINER-MARS 1964 TELECOMMUNICATION SYSTEM

Hunter, J. A.

Technical Report No. 32-836, December 1, 1965
(Unclassified)

This Report describes the radio, telemetry, and command subsystems of the *Mariner-Mars* 1964 telecommunication system and presents a summary of system performance during the mission. For this mission the *Mariner IV* required a telecommunications system providing telemetry, command, and doppler tracking capabilities over ranges approaching 260×10^6 km. By utilizing unique characteristics of the Mars 1964 minimum energy trajectories, it was possible to meet this requirement without a pointable antenna and the associated complex spacecraft equipment. Spacecraft equipment

design was based on techniques used for the *Mariner II* spacecraft, with modifications to increase reliability and accommodate the increased maximum communication range.

Ingham, J. D.

I01 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES. DETERMINATION OF THE CARBON-14 DISTRIBUTION IN THE ISOCYANATE GROUPS OF 2,4-TOLYLENE DIISOCYANATE

Kopka, E. F., Rapp, N. S., Ingham, J. D.

Technical Report No. 32-861 (Unclassified)

(Reprinted from the *Journal of Labeled Compounds*, Vol. 1, No. 3, July-September 1965, pp. 1-2)

For abstract, see Entry K21.

I02 THE MECHANISM OF THERMAL DEGRADATION OF CERTAIN POLYETHER-POLYURETHANS

Ingham, J. D., Rapp, N. S.

Technical Report No. 32-880 (Unclassified)

(Reprinted from *Polymer Engineering and Science*, Vol. 6, No. 1, January 1966, pp. 1-6)

Relatively few publications have appeared that describe basic studies of the thermal degradative processes that can occur in polyether-polyurethans. This article is an account of some studies of the mechanism of degradation of uncross-linked polyurethan prepared from poly(propylene oxide) (PPO) and 2,4-tolylene diisocyanate (TDI) at temperatures up to 320°C in a vacuum or inert atmosphere.

I03 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS

Ingham, J. D., Lawson, D. D., Manatt, S. L.,

Rapp, N. S., Hardy, J. P.

Technical Report No. 32-904 (Unclassified)

(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75-91)

The H^1 and F^{19} spectra of acetates and trifluoroacetates of hydroxy-terminated poly(alkylene oxides) and model diols have been studied, to establish the type and configuration of end-group structures. Because fluorine derivatives produce greatly accentuated chemical shifts, very subtle structural differences were detected. Besides demonstrating the simple determination of the relative concentrations of primary and secondary hydroxyl groups in mixtures of hydroxy compounds, F^{19} NMR was used to establish stereo and positional isomeric configuration of the terminal and next adjacent monomeric units in poly(propylene oxide) and poly(ethylene oxide-propylene oxide) copolymer. Atactic poly(propylene oxide) contains nearly equal concentrations of syndiotactic and isotactic diads at both ends of the polymer chains, showing only a minor amount of stereoselectivity, whereas poly[(+)- λ -propylene oxide] contains only one of the two possible relative stereoconfigurations of the terminal and neighboring asymmetric carbon atoms at the chain ends.

Ditrifluoroacetates of poly(ethylene oxide-propylene oxide) prepared by further addition polymerization of ethylene oxide to poly(propylene oxide) produce different F^{19} chemical shifts, depending on whether only one or more than one ethylene oxide unit is attached to the propylene oxide units. The approach described suggests that even more detailed structural assignments can be established for poly(alkylene oxides), and also for other polymers containing reactive terminal or pendant structures, by application of advanced NMR techniques.

104 ORGANIC SYNTHESIS USING FUSED SALT SYSTEMS: PREPARATION OF A POLYTRIPHENYLENE

Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

For abstract, see Entry O01.

Ivanoff, R. G.

105 POWER SYSTEMS RELATED TO OPERATIONS OF A LANDED PLANETARY CAPSULE

Ivanoff, R. G.
Technical Memorandum 33-238, June 1, 1965
(Unclassified)

This Report summarizes the analyses of power sources that have been proposed for use on space capsules to be landed on the planet Mars. The investigation was occasioned by the need to define the advantages and disadvantages of power sources that could provide power for such a landed capsule. The analysis compares the various sources on the basis of weight, operating time, development status, complexity, impact tolerance, and capability to withstand sterilization. Also included is a discussion of the thermal problems that must be considered in the design of radioisotope power systems for this mission. The Appendixes present detailed comparisons between photovoltaic and radioisotopic power systems.

Jaffe, L. D.

J01 DEPTH OF LUNAR DUST. STRENGTH OF LUNAR DUST. BEARING STRENGTH OF "FAIRY CASTLE" STRUCTURES.

Jaffe, L. D.
Technical Report No. 32-856 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 24, December 15, 1965, pp. 6129-6270)

The appearance of laboratory craters overlain by various thicknesses of sand has been compared with that of lunar craters, 3 to 13,000 meters in diameter, shown in ten photographs obtained by the *Ranger VII* spacecraft. Results obtained are consistent with an interpretation that at least 5 meters of granular material, and probably considerably more, is deposited on the area of *Mare Cognitum* shown in these photographs.

Lunar surface material must have at least enough strength to permit maintenance, against lunar gravity, of the crater wall slopes and heights observed in the *Ranger VII* photographs. Slopes and heights in craters which appear to be overlain with granular material permit setting lower bounds to its strength. The lower bound for the mass bearing capacity is 10 g/cm² on a strip of 0.1-meter width, and 100 g/cm² on a strip of 1-meter width.

To explain the optical properties of the lunar surface, it is suggested that the outer layer is made up of rock particles, a few microns in diameter, which maintain a very high porosity by interparticle adhesion. This is termed a "fairy castle structure." Mechanical property measurements so far published on such structures include compressibility at 14 to 47% solid and cohesion at an undetermined per cent solid measured shear properties at 36 to 44% solid, which is somewhat above the range of interest. Measurements of bearing strength have not previously been reported. The materials used in the present work are silica and alumina.

The primary effect of lunar atmospheric conditions on materials tested is to remove adsorbed surface films and increase interparticle adhesion at the resulting clean surfaces. The values calculated from test results provide only lower bounds for the strength of fairy castles under lunar surface conditions.

J02 LUNAR DUST DEPTH IN MARE COGNITUM

Jaffe, L. D.
Technical Report No. 32-896 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 71, No. 4, February 15, 1966, pp. 1095-1103)

A previously reported technique for preparing and imaging laboratory craters overlain by various thicknesses of granular material has been refined. The resulting photographs have been compared with those obtained by *Ranger VII* spacecraft. Results support the earlier conclusion that the appearance of lunar craters in the *Ranger* photographs is consistent with the presence of at least 5 meters of granular overlay, and probably considerably more, in the area of *Mare Cognitum*.

Jaffe, P.

J03 A GENERALIZED APPROACH TO DYNAMIC-STABILITY FLIGHT ANALYSIS

Jaffe, P.
Technical Report No. 32-757, July 1, 1965
(Unclassified)

A general approach to the analysis of planar flight dynamic-stability investigations is presented and examples are used to discuss the approach. The foundation of the approach is the energy-integral equation, which relates the energy defect during a half cycle, due to the decay, to those factors causing the decay. The equation can accommodate nonlinear aerodynamics, large oscillatory amplitudes, non-symmetric or lift-

ing bodies, and noncontinuous or double-valued aerodynamic coefficients. Examples are presented demonstrating these applications. This Report also suggests that the usual closed-form differential solution may not be properly representing all physical mechanisms producing decay, because of the continuous nature of its formulation.

J04 EFFECT OF BOUNDARY-LAYER TRANSITION ON DYNAMIC STABILITY

Jaffe, P., Prislin, R. H.

Technical Report No. 32-841 (Unclassified)

(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 3, No. 1, January 1966, pp. 46-52)

Extensive free-flight dynamic stability measurements of 10° half-angle cones with laminar and "tripped" boundary layers at supersonic speeds are presented. Free-flight measurements showing the effects of Mach number, center-of-gravity position, and angle-of-attack oscillatory amplitude on dynamic stability are also presented. The measurements were obtained by launching 1-in. in diameter models at controlled angles of attack up to 40° into the oncoming wind-tunnel flow with a low-velocity pneumatic gun. This motion and the corresponding flow patterns were recorded with high-speed motion pictures taken through the schlieren system. Because of the low model Reynolds number in the wind tunnel, it was necessary to induce boundary-layer transition artificially with wire rings. The free-flight results show that dynamic stability is not perceptibly affected by the state of the boundary layer (thick boundary layers resulting from extremely low Reynolds numbers were not considered) but is affected by the amplitude of oscillation. The data are compared with Tobak's potential flow solution and a solution using the Newtonian impact theory at all angles of attack. Free-flight drag and static stability results are also included.

James, J. N.

J05 MARINER IV MISSION TO MARS (PART II)

James, J. N., et al.

Technical Report No. 32-782, September 15, 1965

(Unclassified)

(Reprinted from *Astronautics and Aeronautics*, June, July, and August 1965)

This Technical Report is a series of seven individual papers documenting the *Mariner-Mars* project from its beginning in 1962 following the successful *Mariner-Venus* mission. Part I is *pre-encounter* data. It includes papers on the design, development, and testing of *Mariner IV*, as well as papers detailing methods of maintaining communication with and obtaining data from the spacecraft during flight, and expected results during encounter with Mars.

Part II, *post-encounter* data, to be published later, will consist of documentation of the events taking place during *Mariner IV*'s encounter with Mars and thereafter. The

Mariner-Mars mission, the culmination of an era of spacecraft development, has contributed much new technology to be used in future projects.

Jet Propulsion Laboratory

J06 MARINER-MARS 1964 PROJECT REPORT: MISSION AND SPACECRAFT DEVELOPMENT VOLUME I. FROM PROJECT INCEPTION THROUGH MIDCOURSE MANEUVER

Jet Propulsion Laboratory

Technical Report No. 32-740, March 1, 1965

(Unclassified)

This volume, the first of a series of volumes that comprise the *Mariner-Mars* 1964 Project Report, describes the formation and organization of the project, and traces its development up through the time of the midcourse maneuver. The bulk of this volume describes the development of the spacecraft itself, including design concepts and changes, fabrication and procurement history, and flight performance for the early portion of flight.

The *Mariner-Mars* 1964 mission required the use of a great many new techniques in designing, building, and operating unmanned spacecraft. The success of *Mariner IV* has made these techniques significant, particularly in the light of future space programs. It is hoped that the operations and results documented in this volume will be useful reference to those planning future space missions.

J07 RANGER VIII AND IX. PART I. MISSION DESCRIPTION AND PERFORMANCE

Jet Propulsion Laboratory

Technical Report No. 32-800, January 31, 1966

(Unclassified)

The *Ranger VIII* and *IX* missions successfully concluded the *Ranger* unmanned lunar-investigation project. The Block III *Ranger* spacecraft, launched by the *Atlas/Agna* vehicle and tracked by the Deep Space Network, contained a six-camera television package and had the objective of obtaining high-resolution photographs of the lunar surface prior to impact. *Ranger VIII*, launched February 17, 1965, returned 7137 pictures before its impact in southwestern *Mare Tranquillitatis* on February 20. *Ranger IX* was launched on March 21, 1965, and impacted in the crater Alphonsus on March 24. A successful terminal maneuver performed on *Ranger IX* brought the resolution of the final pictures to 0.4 m; a total of 5814 pictures was obtained from this mission. A brief loss of telemetry during *Ranger VIII*'s midcourse maneuver, apparently caused by a conducting particle forming a temporary short circuit in the spacecraft radio, was the only significant anomaly observed in the two flights. The initial accuracy of the *Ranger IX* launch made it possible to defer the midcourse maneuver 22 hr; the actual impact was within 5 km of the selected aiming point.

Johnson, B. H.

J08 AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF COMBUSTION ON THE MIXING OF HIGHLY REACTIVE LIQUID PROPELLANTS

Johnson, B. H.

Technical Report No. 32-689, July 15, 1965

(Unclassified)

The effects of combustion on the liquid-phase mixing of several storable liquid bipropellants were investigated. It was found that combustion effects were severe when nitrogen tetroxide was used as the oxidizer with various storable fuels, including hydrazine, unsymmetrical dimethylhydrazine, and monomethylhydrazine. Other combinations tested were found to be less affected by the combustion process. Several attempts were made to induce propellant mixing by mechanical means, and the effects of chemical inhibitors on the mixing process were investigated. None of the mechanical and chemical techniques studied influenced the prereaction mixing of the propellants to an appreciable extent.

Johnson, W. R.

J09 FILTERING TECHNIQUES FOR NOISE SUPPRESSION IN QUASI-BALANCED CIRCUITS

Johnson, W. R.

Technical Report No. 32-945, June 15, 1966

(Unclassified)

This Report describes common-mode noise voltages, which may be present in electrical power and signal circuits, and submits means of preventing such noise from interfering with electronic equipment through the proper selection of filters and/or electrostatically shielded isolation transformers. There is a distribution of solutions to the problem. If the problem is generally understood, a solution may be proposed on the basis of the information in this Report.

Filters offer the best means of noise suppression for balanced-mode noise voltages, particularly in the medium- and high-frequency region (> 20 kc). They also yield some attenuation to common-mode noise voltages and may be used for this purpose at high frequencies (> 10 Mc).

Isolation transformers with electrostatic shielding can be effective in eliminating the common-mode noise voltages in the low- and mid-frequency ranges (≈ 0 to 10 Mc).

Balanced or ungrounded circuitry generally loses its identity at high frequencies. Occurrence of capacitive coupling to unwanted grounds results in loss of rejection to common-mode noise. Consequently, it is very desirable, cost and size permitting, to use a filter driving an isolation transformer.

An attempt has been made to define test methods for determining the type of mode present in a circuit. General application of filters and isolation transformers to balanced-mode and common-mode noise voltage problems appears in tabular form.

Johnston, A. R.

J10 DETERMINATION OF THE LOW-FREQUENCY LINEAR ELECTRO-OPTIC EFFECT IN TETRAGONAL BaTiO₃

Johnston, A. R., Weingart, J. M.

Technical Report No. 32-760 (Unclassified)

(Reprinted from *Journal of the Optical Society of America*, Vol. 55, No. 7, July 1965, pp. 828-834)

The magnitude of the linear electro-optic effect at 5461 \AA in single-crystal barium titanate has been determined in the temperature range from 5 to 120°C . The low-frequency or stress-free values were obtained for r_{42} and $r_c = r_{33} - (n_a/n_c)^3 r_{13}$. The polarimetric measurement did not separate r_{33} from r_{13} . The quantity r_{42} was found to vary as K_a , the dielectric constant effective for the a -directed electric field. Similarly, r_c was approximately proportional to $K_c P_s$, the product of the "c" dielectric constant and spontaneous polarization, but did not rise quite as fast as $K_c P_s$ with increasing temperature. The difference was outside experimental uncertainty. The values found at 25°C were $r_c = 1.08 \times 10^{-8} \text{ cm/V}$; $r_{42} = 16.4 \times 10^{-8} \text{ cm/V}$.

J11 THE STRAIN-FREE ELECTRO-OPTIC EFFECT IN SINGLE-CRYSTAL BARIUM TITANATE

Johnston, A. R.

Technical Report No. 32-843 (Unclassified)

(Reprinted from *Applied Physics Letters*, Vol. 7, No. 7, October 1965, pp. 195-198)

The purpose of this Report is to describe an experimental determination of the linear electro-optic effect under the strain-free condition, in single-crystal BaTiO_3 , as a function of temperature between 10 and 120°C , and also, to report a surprisingly large strain contribution to the quadratic electro-optic response above the Curie transition. These results are compared to a previously reported measurement of the low-frequency, or stress-free, response of BaTiO_3 in the tetragonal state.

Jones, D. E.

J12 THE MARINER II MICROWAVE RADIOMETER EXPERIMENT

Jones, D. E.

Technical Report No. 32-722, January 1, 1965

(Unclassified)

Aboard the *Mariner II* spacecraft was a dual-channel microwave radiometer, which obtained three scans across the planet Venus at wavelengths of 13.5 and 19 mm . The relationship of the peak temperature values of the three scans supports a hot-surface model for the planet. Several atmosphere-surface configurations were assumed in an attempt to match the limb-darkening ratios and temperature values measured at both wavelengths. The model that agrees most closely with the data is one that consists of a specular surface and an isothermal cloud-type layer at a temperature near 350°K . The anomaly that occurred toward the end of scan 2 was in the

same region of the planet as that observed by the terrestrial measurements at 8 to 14 microns and is consistent with a marked increase in opacity of the 350°K cloud layer in this region. The marked difference between the 13.5- and 19-mm temperatures indicates the presence of an abrupt discontinuity in the microwave spectrum of Venus that cannot be due to uncondensed water vapor and hence requires the presence of a molecule or molecules in the atmosphere of Venus that condense or polymerize into liquid form at $T \geq 350^\circ\text{K}$ and exhibit line spectra in the vicinity of 13.5 mm and shorter.

The magnitude of the relative dielectric coefficient of the surface is found to lie between 3 and 4. The surface temperature variation that best fits the data is of the form $T_s = 700^\circ\text{K} + (80 \pm 5)^\circ\text{K} \cos \phi$. An upper limit of ~ 100 atmospheres for the surface pressure is obtained for an atmosphere containing 20% CO_2 and 80% N_2 .

Jordan, R. L.

- J13 THE HIGH-ALTITUDE ROCKET RADAR PROJECT**
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Kalfayan, S. H.

- K01 END-GROUP MODIFICATION OF
POLY(ALKYLENE OXIDES).
VOLUME I. CYANOETHYLATION**
Kalfayan, S. H., Havlik, A. J.
Technical Memorandum No. 33-251, December 15, 1965
(Unclassified)

Poly(alkylene oxides) terminated mainly by nitrile groups can be prepared by the alkoxide-catalyzed cyanoethylation of either poly(ethylene oxides) or poly(propylene oxides). Conversion of the nitriles to either amino or carboxyl groups gives compounds that upon reaction with diisocyanates or imines, respectively, could form polymers of use in a systematic study of molecular structure needed for the formation of highly extensible elastomers. To establish a firm basis for the functionality of the modified poly(alkylene oxides), the cyanoethylation of a series of hydroxyl-bearing compounds was studied quantitatively. Results suggest that during cyanoethylation, a side reaction, consisting of block polymerization of acrylonitrile, interferes with the one-to-one conversion of the hydroxyl group to nitrile. The importance of catalyst concentration, the molecular weight of the hydroxylic compound, the ratio of acrylonitrile to hydroxyl-group concentrations, and the temperature to the formation of side-products is discussed. Gas-liquid-partition chromatography is found to be a suitable analytical method for kinetic studies on the cyanoethylation of some hydroxylic compounds.

Kapell, G. F.

- K02 EXPERIMENTAL ASSEMBLY AND STERILIZATION
LABORATORY (EASL) OPERATIONS: PHASE I**
Kapell, G. F., McDade, J. J., Gavin, T. R.
Technical Report No. 32-941, April 15, 1966
(Unclassified)

This Report describes the Experimental Assembly and Sterilization Laboratory (EASL) effort initiated at the Jet Propulsion Laboratory. This document, a final report of Phase I of the EASL effort, presents conclusions and recommendations based on this Phase I study.

Kastel, D.

- K03 STRESS MEASUREMENTS ON BLAIR HIGH
SCHOOL GYMNASIUM: A DEMONSTRATION
OF SPACE TECHNOLOGY TRANSFER**
Kastel, D.
Technical Report No. 32-837, November 1, 1965
(Unclassified)

This Report describes an actual demonstration of transfer to non-space use of technologies developed for space programs applications. Techniques used in assessing static and dynamic characteristics of the Blair High School gymnasium involved data by continuous scanning of strain gauge data acquired over a time of wide-temperature range and analysis by a computer routine developed by Jet Propulsion Laboratory. The advantage of this method over conventional structural testing of uniquely designed structures was proved. The process of demonstration was shown to be of great assistance to, and extension of, normal methods of disseminating information of new technologies. It is felt that significant benefit will derive from this improved mode of concept transfer.

Keil, K.

- K04 POLYMINERALIC INCLUSIONS IN THE
ODESSA IRON METEORITE**
Marshall, R. R., Keil, K.
Technical Report No. 32-807 (Unclassified)
(Reprinted from *Icarus: International Journal of the Solar
System*, Vol. 4, No. 5/6, December 1965, pp. 461-479)

For abstract, see Entry M12.

Keller, O. F.

- K05 ALPS GENERANT TANK AND CELL ASSEMBLY**
Keller, O. F., Toth, L. R.
Technical Report No. 32-865, February 28, 1966
(Unclassified)

A development program was carried out to determine the relative advantages and disadvantages of diaphragm-type bladders as opposed to balloon-type bladders for expulsion of hydrazine to an Advanced Liquid Propulsion System (ALPS). Bladder materials used were limited to butyl and ethylene propylene elastomers. Ribs, molded integrally with the diaphragm-type bladders, were used to increase expulsion

efficiencies at the higher expulsion pressures. Water expulsion tests were made at pressures up to 100 psig using a transparent Plexiglas tank as a full-scale working model to simulate the flight-type generant tank. Two heavy-weight AISI 4130 steel generant tanks were fabricated for testing as part of a *Mariner* 1966 photo-type subsystem utilizing a 50-lb thrust rocket. Expulsion pressures used were generally limited to 1300 psig. One test using hydrazine was conducted to the point of propellant depletion. Three flight-type 6AL-4V titanium generant tanks were fabricated for testing in the ALPS pressurization subsystem. Expulsion pressures were again generally limited to 1300 psig. A detailed description of the fabrication procedure for the flight-type titanium generant tank includes: a discussion of the welding parameters, cooling devices used during welding, the method used to attach the elastomeric diaphragm to the generant tank wall prior to the final girth weld operation, and the procedure used in replacing the diaphragm in the tank.

Kelly, A. J.

K06 ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE EXHAUST OF A MPD SOURCE

Kelly, A. J., Nerheim, N. M., Gardner, J. A.

Technical Report No. 32-796, September 15, 1965
(Unclassified)

Electron density and temperature profiles were measured in the exhaust of a Magneto-Plasma-Dynamic (MPD) source, operated in a vacuum facility which provides background pressures of from ~ 100 to $\sim 1,000 \mu$. Electron density profile measurements, made at several stations downstream of the source by using a Langmuir probe (flushed prior to each measurement) and a 24-Gc/sec microwave swinging arm probe, show agreement to within a factor of two over their common range of measurement ($2 \times 10^{12} \text{ cm}^{-3} \rightarrow 7 \times 10^{12} \text{ cm}^{-3}$). Spectroscopic measurements, utilizing relative ion line intensities at the exit plane of the source, yield electron temperatures in the range 16,000 to 20,000°K for argon mass flows of 0.2 to 0.5 g/sec and currents of 750 to 2,000 amp. Electron temperature profiles, measured 56 cm downstream of the source, have maximums of 6,000 to 7,000°K, which are consistent with collision frequency data obtained with the microwave probe at this station.

It is concluded that the plasma generated by the MPD source is in a highly nonequilibrium state. The degree of ionization at the exit of the source is lower than the equilibrium value based on the measured electron temperature. In the fully developed plume, electron temperature and density measurements show that the degree of ionization is higher than equilibrium.

K07 AN EXPERIMENTAL FEASIBILITY STUDY OF INJECTANT MATERIALS TO ALLEVIATE MARS ENTRY COMMUNICATION BLACKOUT
Kelly, A. J.

Technical Report No. 32-835, November 15, 1965
(Confidential)

An experimental program has been initiated to establish the feasibility of using various appropriate materials, injected into the spacecraft wake, as a means of reducing the free-electron density level sufficiently to eliminate its interference with telemetry. It has been determined that the flow conditions (pressure, temperature, electron density) anticipated behind the bow shock of a blunt Martian entry body can be accurately simulated by the plume from an energetic magneto-plasma-dynamic (MPD) arc source.

Electron density profile data were obtained for various injectant materials. From these data, the most promising injectant material was selected and studied more extensively.

K08 ANALYSIS OF THE INTERACTION OF THE SURVEYOR RADAR ALTIMETER DOPPLER VELOCITY SENSOR SYSTEM AND VERNIER THRUST CHAMBER PLUMES

Kelly, A. J.

Technical Report No. 32-927, April 15, 1966
(Unclassified)

In keeping with guidelines of the study task outlines, this analysis was specifically conducted to provide conservative estimates of the vernier plume/RADVS-system interactions effects. In all instances, operating conditions were assumed which, while consistent with *Surveyor* system specifications, would exaggerate the RADVS-plume interaction. For example, the vernier propellant specifications permit a maximum total impurity concentration of 500 ppm. Actually, the propellant purity level is known, from test, to be at least an order of magnitude less than the specifications. However, for the purpose of this investigation, the propellant was assumed to have 500 ppm of sodium as an impurity. As with all other assumptions made during the course of analysis, this assumption permitted an upper bound to be placed on the interaction of the vernier plumes and the RADVS system. As a consequence, no attempt was made to provide a detailed assessment of the most probable level of RADVS-plume interaction to be expected under nominal *Surveyor* operating conditions.

The maximum calculated two-way attenuation and reflection level are both well below the levels at which the performance of the RADVS system would be significantly influenced. However, the nonstatic two-way phase-shift was found to be in excess of the level above which the operation of the RADVS system would be affected.

Kelly, J. H.

K09 DEVELOPMENT OF THE POST-INJECTION PROPULSION SYSTEM FOR THE MARINER-C SPACECRAFT

Schmitz, B. W., Groudle, T. A., Kelly, J. H.

Technical Report No. 32-830, April 1, 1966
(Unclassified)

For abstract, see Entry S05.

Kendall, W. B.

K10 UNAMBIGUOUS ACCURACY OF AN INTERFEROMETER ANGLE-MEASURING SYSTEM

Kendall, W. B.

Technical Report No. 32-781 (Unclassified)

(Reprinted from *IEEE Transactions on Space Electronics and Telemetry*, Vol. SET-11, No. 2, June 1965, pp. 62-70)

In this paper the problem of using signals received at three or four antennas to estimate the direction from which radio-frequency (RF) radiation is arriving is under consideration. Though the results are couched in the terminology of angle measurements, they are applicable to any ambiguous measurements for which the number of ambiguities is inversely proportional to the accuracy. For an interferometric system the effect of receiver noise is examined. Then the optimum way to process the received waveforms, and the best spacing for the antennas, is determined. Next, signal-to-noise ratio (SNR) requirements are determined which must be met to ensure that, with a given probability, the final unambiguous measurement is not in error by more than some specified amount. Finally, a comparison is made between a system which uses unambiguous measurements and a system which uses ambiguous measurements and then resolves the ambiguities.

Kerrisk, D. J.

K11 PLASMA NONUNIFORMITY AND GRID EROSION IN AN ELECTRON BOMBARDMENT ION ENGINE

Kerrisk, D. J., Masek, T. D.

Technical Report No. 32-738 (Unclassified)

(Reprinted from the *AIAA Journal*, Vol. 3, No. 6, June 1965, pp. 1060-1066)

The plasma in an electron bombardment ion engine of the Kaufman type has been found to be very nonuniform at the ion emission surface. This could lead to a nonuniform sputtering erosion and the destruction of the accelerator grid. The plasma density has been measured with a Langmuir probe and the ion beam profile with a Faraday probe. Together with flow-rate measurements, this gives an experimental determination of N_0N^+ . Sputtering, as a function of radial position, was measured using a segmented accelerator grid, and variations in the erosion rate were correlated to the variations in N_0N^+ . Results indicate that the engine lifetime estimates based on average grid erosion rates will be high by a factor of 2 to 3, considering only the charge-exchange erosion contribution.

King, J., Jr.

K12 THEORY OF THE LOW-TEMPERATURE CHROMATOGRAPHIC SEPARATION OF THE HYDROGEN ISOTOPES

King, J., Jr., Benson, S. W.

Technical Report No. 32-870 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*, Vol. 44, No. 3, February 1966, pp. 1007-1014)

A new electrostatic theory is presented which quantitatively explains the chromatographic separation of the hydrogen isotopes on an alumina column at low temperatures. The theory is based on the interaction of the surface electric fields of the alumina with the polarizable hydrogen isotopes. By calculating the electric fields over an adopted Al_2O_3 surface, it is found that there are two active adsorption sites at 77.4°K, one over a vacancy in the Al_2O_3 structure, and the other over an Al^{3+} . The total interaction potential over either site is a function of the polarizabilities of the adsorbed molecules and the distance the molecules are from the surface. A 5-9 potential over a vacancy site gives results which favorably agree with experimental values. The rotational barrier, necessary to explain the separation of the ortho and para species, is shown to arise from the difference in the parallel and perpendicular components of the molecular polarizability of the hydrogen molecule.

K13 ELECTROSTATIC INTERACTIONS IN GAS-SOLID CHROMATOGRAPHY

King, J., Jr., Benson, S. W.

Technical Report No. 32-905 (Unclassified)

(Reprinted from *Analytical Chemistry*, Vol. 38, No. 2, February 1966, pp. 261-265)

An electrostatic theory of physical adsorption is applied to gas-solid chromatography and predicts the elution order of many gases from columns. When applied to the separation of the rare gases and methane on a $\gamma-Al_2O_3$ column at room temperature the theory not only gives the correct elution order, but it also quantitatively explains the behavior of methane on the column. The theory gives a qualitative explanation of the chromatographic inseparability of argon and oxygen at room temperature. The application of the theory to molecular sieve column leads to the suggestion that adsorption on molecular sieves is very similar to adsorption on other adsorbents like $\gamma-Al_2O_3$ and silica gel. The theory proposes that adsorption on all of these adsorbents is governed by electrostatic interactions. This concept when applied to sieve columns leads to refutation of the accepted hypothesis that the separation of molecules on the column is caused by some type of "sieve" action.

Kinkel, J. R.

K14 RELIABLE TIME MULTIPLEXING BY REPLACEMENT

Kinkel, J. R.

Technical Report No. 32-828, November 15, 1965

(Unclassified)

This Report describes a switching array for time multiplexing using active redundancy at the function level and passive redundancy at the component level to increase reliability. It has been divided into two parts: (1) a description of the multiplexer, and (2) a computer verification of its behavior.

Analysis of the multiplexer is based on failure modes instead of failure probabilities. The computer simulation verifies that failure localization occurs, and that it extends the useful life of the multiplexer.

Kirhofer, W. E.

- K15 EARTH-MOON TRAJECTORIES, 1960-70**
Richard, R. J., Clark, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

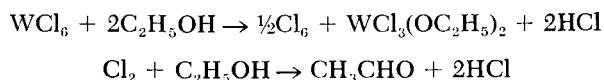
For abstract, see Entry R12.

Klejnot, O. J.

- K16 CHLORIDE ALKOXIDES OF PENTAVALENT TUNGSTEN**
Klejnot, O. J.
Technical Report No. 32-863 (Unclassified)
(Reprinted from the *Inorganic Chemistry*, Vol. 4, No. 11, November 1965, pp. 1668-1670)

Studies aimed at syntheses of the unknown tungsten hexa- and pentaalkoxides have led to the first isolation of tungsten(V) chloride alkoxydes (I-III). The reported green $W_2Cl_1(OC_2H_5)_6$ obtained by reducing pentavalent solutions seems to be tetra- valent with two ethanol ligands in place of two ethoxy ligands.

Dissolution of tungsten hexachloride in alcohols gave long- known yellow solution, but the evolution of chlorine in methanol or ethanol has only been noted now



Klevans, E. H.

- K17 TEMPERATURE RELAXATION IN A FULLY IONIZED PLASMA**
Wu, C.-S., Klevans, E. H., Primack, J. R.
Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 6, June 1965, pp. 1126-1133)

For abstract, see Entry W32.

Knoell, A. C.

- K18 ENVIRONMENTAL AND PHYSICAL EFFECTS ON THE RESPONSE OF BALSA WOOD AS AN ENERGY DISSIPATOR**
Knoell, A. C.
Technical Report No. 32-944, June 15, 1966
(Unclassified)

The description includes the balsa-wood development program, balsa-wood specimens, static testing, and an analysis

and discussion of test results. This document also comprises a list of conclusions based on the investigation.

Koester, H.

- K19 THE USE OF CONVENTIONAL WIND TUNNELS TO SIMULATE PLANETARY ATMOSPHERIC AERODYNAMICS**
Koester, H., Fox, N.
Technical Report No. 32-762, November 15, 1965
(Unclassified)

The aerodynamic effects of planetary atmospheric simulation have been experimentally investigated in the Jet Propulsion Laboratory wind tunnels. Admixtures of carbon dioxide into the conventional dried air working fluid were used to simulate variations of the atmospheric properties. The performance of the wind tunnels, the techniques used, and samples of the data obtained are presented. The results obtained indicate that, within a given range, this approach will yield excellent data for planetary atmosphere entry vehicle design.

Kopf, E. H., Jr.

- K20 AN ADAPTIVE NUMERICAL INTEGRATION ROUTINE FOR THE IBM 1620 II**
Kopf, E. H., Jr.
Technical Report No. 32-962, June 1, 1966
(Unclassified)

This Report presents a symbolic-programming-system coded numerical integration program designed to be used as a FORTRAN subroutine on the IBM 1620 II Computer. The program will solve differential equations by integration starting with known initial conditions. An adaptive option is available where the speed of integration is automatically varied in accordance with a predicted error.

Kopka, E. F.

- K21 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES. DETERMINATION OF THE CARBON-14 DISTRIBUTION IN THE ISOCYANATE GROUPS OF 2, 4-TOLYLENE DIISOCYANATE**
Kopka, E. F., Rapp, N. S., Ingham, J. D.
Technical Report No. 32-861 (Unclassified)
(Reprinted from the *Journal of Labeled Compounds*, Vol. 1, No. 3, July-September 1965, pp. 1-12)

A practical phosgenation procedure has been devised for the preparation of isocyanates labeled with ^{14}C . Three such isocyanates: 2-tolyl isocyanate, 4-tolyl isocyanate, and 2,4-tolylene diisocyanate (TDI) were prepared. The ^{14}C distribution in the latter was determined by scintillation counting of some of its derivatives, one of which was 3-amino-4,2',6'-trimethylcarbanilide, from which the fraction of ^{14}C in the 4-isocyanate group of TDI was obtained.

Kotlensky, W. V.

K22 TENSILE AND STRUCTURAL PROPERTIES OF GLASSY CARBON

Kotlensky, W. V., Fischbach, D. B.

Technical Report No. 32-842, November 15, 1965
(Unclassified)

Tensile properties of two different grades of glassy carbon (GC-20 and GC-30) have been measured from room temperature to 2900°C. The test specimens had a gauge section 0.08 in. in width by 0.10 in. in thickness with a 0.75-in. gauge length. Tests were made in a helium atmosphere, and heating was accomplished by means of an external graphite heater. Tensile strengths at room temperature for both grades were approximately 6000 psi. Both grades showed an increase in strength with increasing test temperature, reaching a maximum within the 20,000 to 25,000 psi range at 2500°C. At 2900°C, strengths of about 12,000 psi for GC-20 and 16,000 psi for GC-30 were measured. Differences in the deformation of the two grades were evident from their ductility. At 2700°C, maximum elongations of 33% for GC-20 and 5.4% for GC-30 were measured. Density, unit cell dimension, hardness, and diamagnetic susceptibility measurements were used to investigate the structural changes accompanying deformation and heat treatment. Electron micrographs revealed a difference in fracture mode for GC-20 and GC-30. The tensile and structural behavior of glassy carbon has been compared with that of conventional carbon-base materials. It is suggested that cross-link bonding is responsible for the high strength of glassy carbon; however, the small crystallite size and the small pore size may also be contributing factors.

K23 ANALYSIS OF HIGH TEMPERATURE CREEP IN PYROLYTIC CARBON

Kotlensky, W. V.

Technical Report No. 32-889, February 15, 1966
(Unclassified)

Data on short-time high-temperature tensile creep parallel to the substrate for two pyrolytic carbons (pyrolytic graphites) characterized by their microstructures as substrate nucleated (SN) and regeneratively nucleated (RN) have been analyzed by means of the Dorn method. Over the range of approximately 1.5 to 10% creep strain for the SN material and for creep strains above 1.5% for the RN material, the creep data were found to fit the empirical relationships $\epsilon = A + Bt^n$, where ϵ is the creep strain, t is the time, n is a constant that depends on the material, and A and B are parameters that depend on both the material and the test conditions. The SN material was characterized by $n = 0.60$, while the RN material had $n = 0.42$. The same apparent activation energy of about 250 kcal/mole was calculated for both of these carbons. As assumed in the analysis, the structural change that occurs during creep was found to be dependent on the total creep strain, and the same structure was developed at a given load for the same strain, independent

of test temperature. These structural changes are discussed briefly with reference to the deformation mechanisms.

Kuiper, G. P.

K24 RANGER VIII AND IX.

PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS

Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.

Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

Kuwada, D.

K25 PYROLYSIS STUDIES. CONTROLLED THERMAL DEGRADATION OF MESOPORPHYRIN

Whitten, D. G., Bentley, K. E., Kuwada, D.

Technical Report No. 32-812 (Unclassified)
(Reprint from the *Journal of Organic Chemistry*, Vol. 31, 1966, pp. 322-324)

For abstract, see Entry W22.

Laderman, A.

L01 THE HIGH-ALTITUDE ROCKET RADAR PROJECT

Brown, W. E., Jr., Barath, F. T., Jordan, R. L., Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.

Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Landel, R. F.

L02 THE TENSILE FAILURE ENVELOPE OF AMORPHOUS ELASTOMERS: EFFECTS OF STATISTICAL VARIABILITY AND CROSSLINK DENSITY

Landel, R. F., Fedors, R. F.

Technical Report No. 32-633 (Unclassified)
(Reprinted from the *Proceedings of the Fourth International Congress On Rheology*, Brown University, Providence, R.I., August 26-30, 1963, Interscience Publishing Co., New York, 1965, pp. 543-566)

The statistical variability of both rupture stress, σ_b , and rupture strain, ϵ_b , was studied by breaking 25 ring specimens of peroxide cured SBR at a strain rate of 2.32/min at 23, -10 and -40°C. The statistical distribution for both σ_b and ϵ_b can be reasonably described by a double-exponential cumulative distribution function whose parameters are temperature dependent and presumably depend on the test rate and the concentration of effective network chains as well. The rupture points plotted as a Smith failure envelope, $\log \sigma_b T_0/T$ vs $\log \epsilon_b$, where T_0/T is the usual temperature reduction factor, define the same envelope as that determined by breaking single specimens at varying rates and temperatures.

It is demonstrated that the high temperature portions of the failure envelopes of some 12 systems, including butyl, epoxy, SBR, ethylene-propylene, silicone, and Viton B rubbers, could be superposed to a single master curve by normalizing σ_b to unit chain concentration and to a common number of degrees above T_g ($T_g + 100$ in the present case). The form of the master curve can be described reasonably well by the Martin-Roth-Stiehler expression for the stress-strain curve of an elastomer,

$$\sigma = E\epsilon\lambda^{-2} \exp [0.40 (\lambda - \lambda^{-1})].$$

It is also pointed out that for systems which follow the master curve, the concentration of effective network chains can be rapidly and conveniently determined by breaking multiple specimens at an appropriate rate and temperature and comparing the resulting portion of the failure envelope with the master curve.

- L03 STATISTICAL VARIABILITY OF ULTIMATE PROPERTIES OF SBR GUM VULCANIZATES**
Fedors, R. F., Landel, R. F.
Technical Report No. 32-783 (Unclassified)
(Reprinted from *Transactions of the Society of Rheology*, Vol. 9, No. 1, 1965, pp. 195-218)

For abstract, see Entry F02.

- L04 ORGANIC SYNTHESIS USING FUSED SALT SYSTEMS: PREPARATION OF A POLYTRIPHENYLENE**
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

For abstract, see Entry O01.

Lang, T. E.

- L05 SUMMARY OF THE FUNCTIONS AND CAPABILITIES OF THE STRUCTURAL ANALYSIS SYSTEM COMPUTER PROGRAM**
Lang, T. E.
Technical Memorandum No. 33-220, June 15, 1965
(Unclassified)

The functions and operations of a large capacity Structural Analysis System Computer Program developed to analyze frame and shell-type structures are described. Included is a summary of the capabilities of the program, and a discussion of certain problems encountered in development of the program. The participation of engineering personnel in the setup and running of a typical shell problem is outlined.

Laudenslager, R. K.

- L06 EXPERIMENTAL PROCEDURES FOR MOLECULAR WEIGHT DETERMINATION BY LIGHT SCATTERING**
Beattie, W. H., Laudenslager, R. K., Moacanin, J.

Technical Memorandum No. 33-242, January 1, 1966
(Unclassified)

For abstract, see Entry B09.

Laue, E. G.

- L07 MEASUREMENT DEVICES HAVING POTENTIAL APPLICATION TO SOLAR SIMULATION SYSTEMS**
Laue, E. G.
Technical Report No. 32-925 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 3, No. 3, March 1966, pp. 378-382)

The four major parameters of a solar simulation system (radian flux density, uniformity of flux density, decollimation angle, and spectral distribution of energy) require careful evaluation before meaningful testing can be accomplished. Working conditions and schedule problems preclude the use of instruments which require precise and time-consuming adjustments. The use of photovoltaic detectors (silicon solar cells, selenium cells, and modified germanium transistors) with interference filters and simple optical devices provide a means of rapidly acquiring the necessary data but do not eliminate the necessity for careful and thorough preliminary testing using precision instruments.

Lawson, D. D.

- L08 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS**
Ingham, J. D., Lawson, D. D., Manatt, S. L., Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75-91)

For abstract, see Entry I03.

- L09 ORGANIC SYNTHESIS USING FUSED SALT SYSTEMS: PREPARATION OF A POLYTRIPHENYLENE**
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

For abstract, see Entry O01.

Leipold, M. H.

- L10 MASS SPECTROGRAPHIC ANALYSES OF NONCONDUCTING CERAMICS**
Socha, A. J., Leipold, M. H.
Technical Report No. 32-815 (Unclassified)
(Reprinted from the *Journal of the American Ceramic Society*, Vol. 48, No. 9, September 1965, pp. 463-466)

For abstract, see Entry S21.

Levine, H. B.

- L11 MANY-ELECTRON-THEORY AB INITIO CALCULATION FOR THE Be ATOM**
Geller, M., Taylor, H. S., Levine, H. B.
Technical Report No. 32-799 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 5, September 1965, pp. 1727-1736)

For abstract, see Entry G06.

Likins, P. W.

- L12 EFFECTS OF ENERGY DISSIPATION ON THE FREE-BODY MOTIONS OF SPACECRAFT**
Likins, P. W.
Technical Report No. 32-860, July 1, 1966
(Unclassified)

The objective of this study is the development of methods of analysis of the motions of spacecraft modeled as nonrigid, dissipative bodies in a force-free environment. In the absence of external forces, angular momentum is conserved, but, because of internal energy dissipation effects, gross changes in body orientation and rotational motion may occur. Three analytical methods for the prediction of these changes are developed or described in this Report.

The first method, based on a model of a spacecraft as a rigid body with an "energy sink," has been described in numerous papers in the technical literature. The method is discussed and documented, and limitations in its application are noted.

The second method involves the dynamical analysis of a discrete parameter model of a spacecraft, including discrete dampers. This method, which, analytically, is the most straightforward of the three, is described briefly, and its range of application to spacecraft is defined.

In the third method, a modal model is utilized; i.e., motions are described in terms of the normal modes of deformation of a slightly flexible, lightly damped structure. The primary advantage of this method stems from the improved likelihood of reasonable estimation of structural damping characteristics in early stages of design and of approximate measurement of these characteristics prior to launch. Equations of motion constructed for this model are linearized in the deformation coordinates, but they remain nonlinear in "rigid body motion" coordinates, thus accommodating large angular motions of bodies undergoing small elastic deformations.

Lindley, P. L.

- L13 THE PN TECHNIQUE OF RANGING AS APPLIED IN THE RANGING SUBSYSTEM MARK I**
Lindley, P. L.
Technical Report No. 32-811, November 15, 1965
(Unclassified)

Starting with the basic principles of radar, the concepts of a technique of range determination with pseudo-random codes are developed. Increasingly complex requirements are considered and satisfied in turn by the use of the Gedanken-Experimente approach. The need for ranging codes, their requirements, synthesis, and detection are discussed. A brief functional description of the ranging subsystem Mark I is combined with its performance parameters, including the maximum unambiguous range determinable and the resolution and accuracy of the measurement.

Lindsey, W. C.

- L14 CODED NONCOHERENT COMMUNICATIONS**
Lindsey, W. C.
Technical Report No. 32-739 (Unclassified)
(Reprinted from the *IEEE Transactions on Space Electronics and Telemetry*, Vol. SET-11, No. 1, March 1965, pp. 6-13)

This paper presents detailed results on the relative merits of encoding blocks of binary digits into a set of equiprobable, equal energy, orthogonal signals each containing n bits of information. Word and bit error probabilities are graphically illustrated for various degrees of coding and for various forms of the channel model. Particular emphasis is placed on the Gaussian channel. Special cases of Viterbi's results for coded phase-coherent communications are compared with those obtained in this paper. Bandwidth considerations are also discussed.

The results are useful to the engineer who is faced with the problem of designing coded communications systems where power is limited to the point that phase coherence cannot be established at the receiver.

- L15 OPTIMUM COHERENT LINEAR DEMODULATION**
Lindsey, W. C.
Technical Report No. 32-787 (Unclassified)
(Reprinted from *IEEE Transactions on Communication Technology*, Vol. COM-13, No. 2, June 1965, pp. 183-190)

Presented is the performance analysis for four types of linear-modulated communication systems where the message to be transmitted comes from one of two classes of stochastic processes, and the additive channel noise is white and Gaussian. The two classes of stochastic processes which are used to modulate the transmitter are taken to be the "maximally flat" and "asymptotically Gaussian" processes. Demodulation is accomplished at the receiver by coherent frequency translation using a noisy replica of the carrier and filtering the result with one of two types of Wiener filters. These are commonly referred to as the zero-lag (realizable) and infinite-lag (nonrealizable) Wiener filters.

The four types of modulation considered are: linear-modulation, double-sideband (DSB); linear-modulation, double-sideband, suppressed carrier (DSB/SC); linear-modulation, single-sideband (SSB); and linear-modulation, single-sideband, suppressed carrier (SSB/SC).

Loomis, A. A.

**L16 SOME GEOLOGIC PROBLEMS OF MARS
(REVISION 1)**

Loomis, A. A.

Technical Report No. 32-400 (Unclassified)

(Reprinted from *Geological Society Bulletin*, Vol. 76,
October 1965, pp. 1083-1104)

Data on the body of Mars are as yet insufficient to allow computation of meaningful models of the internal structure or density stratification within the planet. The flattening of the solid surface appears to be greater than the flattening of the equipotential surface by about a factor of two. The resultant possibility that the equatorial regions are high compared to the polar areas has many geological and biological implications.

Most of the inner planets—Mercury, Venus, Earth, Moon, and Mars—have bulk compositions which differ from one another as well as from that of the stony meteorites. The thermal histories of the planets have therefore differed because of different original compositions as well as different sizes and distances from the Sun.

More data on the surface topography are required in order to make geological interpretations which are not largely subjective. The dark areas could be either highlands or lowlands relative to surrounding bright areas. Although sharp relief of several thousand feet is probably absent or nearly so, substantial mountain ranges, plateaus, or basins could exist if the slopes on their flanks are gradual. Liquid water cannot exist on the surface of Mars, and aqueous erosion features, if they once existed, have become subdued by aeolian activity.

Winds on Mars may move more and coarser materials than winds on Earth. Deep accumulations of aeolian deposits have formed, at least locally. *Mariner IV* pictures show an impact-crater distribution much like the highland areas of the Moon. Many craters with original depths of less than about 8000-10,000 feet have become obliterated on Mars by windblown dust.

**L17 A LUNAR AND PLANETARY PETROGRAPHY
EXPERIMENT**

Loomis, A. A.

Technical Report No. 32-785, July 15, 1965
(Unclassified)

A preliminary model of a petrographic microscope for lunar and planetary missions has been fabricated. It is designed primarily for remote operation on soft-landing spacecraft, but could be adapted for support of a manned mission. The sample is not a thin section, but an aggregate of crushed rock particles. The image is projected from an air-gapped 16X refracting objective lens through interchangeable eye-piece lenses onto the faceplate of a television camera. The sample particles are thermally encapsulated between two opposing sheets of a clear isotropic thermoplastic ($n = 1.54$). A television picture is taken both below and above the plane of correct focus as well as in that plane for each field of view

in order to change the Becke line positions. Each grain is viewed in both plane-polarized and cross-polarized light; the spectral width is small enough to provide dark and light interference rings on a black-and-white TV. The primary use of the microscope is observation of rock textures. Secondary uses are determination of bulk mineralogy, observation and compositional estimation of glass, identification of phases which occur in small amounts, and identification of the different rock or mineral types in an originally particulate sample.

Lorell, J.

**L18 LONG TERM BEHAVIOR OF ARTIFICIAL
SATELLITE ORBITS DUE TO THIRD-BODY
PERTURBATIONS**

Lorell, J.

Technical Report No. 32-851 (Unclassified)

(Reprinted from *The Journal of the Astronautical Sciences*,
Vol. 12, No. 4, Winter, 1965, pp. 142-149)

The long term motion of a satellite perturbed only by a third body is studied in detail. Two integrals of the motion are used to classify the possible orbits and to identify the various special cases which represent transition from one family of orbits to another. Results are explained with the help of a set of graphs showing the variation of the Kepler elements along different orbits.

**L19 CHARACTERISTICS AND FORMAT OF THE
TRACKING DATA TO BE OBTAINED BY THE
NASA DEEP SPACE INSTRUMENTATION FACILITY
FOR LUNAR ORBITER**

Lorell, J., Anderson, J. D., Sjogren, W. L.

Technical Memorandum No. 33-230, June 15, 1965
(Unclassified)

This document is intended as an explanatory supplement for users of the data, to explain the meaning of the data, the locations of the instruments, the biases, the precision and accuracy, the reduction to geometrical quantities, and the format for distribution.

Ludwig, A. C.

**L20 LARGE ANTENNA APERTURES AND ARRAYS FOR
DEEP SPACE COMMUNICATIONS**

Potter, P. D., Merrick, W. D., Ludwig, A. C.

Technical Report No. 32-848, November 1, 1965
(Unclassified)

For abstract, see Entry P11.

Lunine, L. R.

**L21 THE SPACE FLIGHT OPERATIONS FACILITY
DOCUMENT CONTROL DATA STORAGE AND
RETRIEVAL SYSTEM**

Higgins, M. D., Lunine, L. R.

Technical Memorandum No. 33-288, June 15, 1966
(Unclassified)

For abstract, see Entry H17.

Lushbaugh, W. A.

L22 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.
Technical Report No. 32-772, December 1, 1965
(Unclassified)

For abstract, see Entry A08.

Lyttleton, R. A.

L23 THE EFFECT OF THE LUNAR ORBIT OF METEORITIC ACCRETION

Lyttleton, R. A.
Technical Report No. 32-293, Part II (Unclassified)
(Reprinted from *Icarus: International Journal of the Solar System*, Vol. 5, No. 2, March 1966, pp. 162-164)

Reduction of the lunar distance through meteoric impacts depends only on the amount of incoming material and scarcely at all on how much may be exploded off the surface to escape. This is because the incoming material possesses negligible angular momentum on average, while outgoing material carries with it the same angular momentum per unit mass as the Moon. To reduce the lunar distance by $\frac{1}{2}$, an amount of matter of about $\frac{1}{4}$ the mass of the Moon would need to have interacted with it, but rounding up from an eccentric orbit without change of angular momentum would be a more likely result.

L24 ON THE PHASE-CHANGE HYPOTHESIS OF THE STRUCTURE OF THE EARTH

Lyttleton, R. A.
Technical Report No. 32-810 (Unclassified)
(Reprinted from the *Proceedings of the Royal Society*, Vol. 287, 1965, pp. 471-493)

The hypothesis that the liquid core of the Earth represents a phase-change at high pressure (and suitable temperature) of the mantle material is further investigated. A more accurate series of two-zone models have been computed, and also a new series of three-zone models. The change of over-all radius as between an original all-solid Earth and the present size is shown to be at least 370 km.

In the outer regions, greater pressure may be needed with rising temperature to effect the transition to denser crystal form (associated with the 20°-discontinuity), and from this cause acting alone slight expansion of the Earth would result, but to an extent less than one-tenth the over-all contraction. Epochs of rapid contraction (mountain-building eras) could thus be separated by longer intervals of very slow expansion.

The initial liquefaction of the central regions brings about pressure increase of the boundary of the core that renders the Earth unstable in that about 6% of the entire mass liquefies extremely rapidly to cause a sudden collapse of the planet as a whole. The accompanying decrease of outer radius is about

70 km. Thereafter the planet remains thoroughly stable and contracts only slowly.

The total contraction to date would have reduced the moment of inertia by a factor of about 4/5, and the corresponding reduction in rotation period (through conservation of angular momentum) would be an effect comparable with tidal friction. The contraction also leads to release of gravitational energy at an average rate comparable with that from radioactive sources.

An important consequence of the phase-change hypothesis is that the melting-point gradient changes sign after sufficient depth, thereby permitting melting of the central regions to occur at moderate temperatures explicable by a reasonable content of radioactive elements.

MacGlashan, W. F., Jr.

M01 GENERANT CONTROLLER DEVELOPMENT FOR THE ADVANCED LIQUID PROPULSION SYSTEM (ALPS)

MacGlashan, W. F., Jr.
Technical Report No. 32-814, November 15, 1965
(Unclassified)

The generant controller is essentially a remote-sensing, single-stage, spring-loaded regulator. Four controller versions were built and tested. Controller 4 incorporates the best features of the preceding three controllers. Results of water tests that simulate expected operating conditions are recorded.

Special features of these controllers, such as the diaphragm backup ring and the Belleville spring package which were developed as a result of this study, are discussed. The suitability of these special features for scalability and for other components is pointed out.

An Appendix is included which describes the function of the generant controller in the ALPS system and in the *Mariner-Mars* 1966 system.

M02 FILL VALVE DEVELOPMENT FOR THE ADVANCED LIQUID PROPULSION SYSTEM (ALPS)

MacGlashan, W. F., Jr.
Technical Report No. 32-875, February 1, 1965
(Unclassified)

A simple, compact, lightweight valve was developed to satisfy the need for reliable fill valves for the Advanced Liquid Propulsion System (ALPS). Manually operated valves for on-off control of Earth-storable propellants and inert gases were designed, built, and tested.

The preferred valve design consists of a ceramic ball, a screw, and a tank boss. The screw pushes the ball onto a spherically lapped seat in the tank boss. With the ground fitting engaged, the valve can be actuated irrespective of line pressure. Flow can be either around or through the screw.

Several variations of this ball valve are described. Problems encountered, refinements, and test results are discussed.

Magistrale, V.

M03 JPL SPACECRAFT STERILIZATION TECHNOLOGY PROGRAM: A STATUS REPORT

Drummond, D., Magistrale, V.

Technical Report No. 32-853, December 31, 1965
(Unclassified)

For abstract, see Entry D08.

Mallory, F. B.

M04 THE RATES OF SOME DEGENERATE REARRANGEMENTS AS DETERMINED BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Mallory, F. B., Manatt, S. L., Wood, C. S.

Technical Report No. 32-857 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 23, December 1965, pp. 5433-5438)

The rates and the activation parameters have been determined for the degenerate isomerizations of three different symmetrically disubstituted benzofurazan oxides in order to provide evidence for the mechanism of this type of interconversion. The rates of these very rapid processes were deduced from the line shapes of the nmr spectra of the three compounds at various temperatures in the range from -40 to $+50^{\circ}$. The positive entropies of activation (ranging from $+4$ to $+6$ e.u.), the relatively small energies of activation (ranging from 15.0 to 16.5 kcal/mole), and the correlation of the relative rates with the size of the substituents at the 4- and 7-positions flanking the N_2O_2 grouping are all considered to support an interconversion mechanism that involves ring opening of the furazan oxide to the corresponding o-dinitroso-benzene as the rate-determining step, followed by very rapid recyclization of this symmetrical intermediate to the heterocyclic N-oxide.

Manatt, S. L.

M05 THE RELATIVE SIGNS OF THE NUCLEAR MAGNETIC RESONANCE PROTON-PROTON COUPLING CONSTANTS IN STYRENE SULFIDE AND STYRENIMINE

Manatt, S. L., Elleman, D. D., Brois, S. J.

Technical Report No. 32-746 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2220-2225)

From nmr double resonance experiments in which a weak perturbing radio-frequency field was applied to certain spectral lines, it was found that the 1.37-cps geminal proton-proton coupling of styrene sulfide (III) is a different sign than the two vicinal couplings of 5.55 and 6.60 cps between protons in the thiirane ring. Similar experiments on styrenimine (II) showed that the 0.87-cps geminal coupling in this molecule is the same sign as the 3.29- and 6.12-cps vicinal couplings in the aziridine ring. These results are discussed in relation

to the magnitudes and relative signs of other geminal and vicinal proton-proton coupling constants and their correlation with substituent electronegativities. It is concluded that the linear correlations of geminal and vicinal couplings with substituent electronegativities may be better than previously expected.

M06 NITROGEN ANALOGS OF SESQUIFULVALENE. II. THEORETICAL CORRELATION OF GROUND-STATE PROPERTIES

Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.

Technical Report No. 32-776 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2901-2907)

For abstract, see Entry B17.

M07 NITROGEN ANALOGS OF SESQUIFULVALENE. III. THEORETICAL CORRELATION OF EXCITED-STATE PROPERTIES

Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.

Technical Report No. 32-776 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2908-2913)

For abstract, see Entry E10.

M08 THE RATES OF SOME DEGENERATE REARRANGEMENTS AS DETERMINED BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Mallory, F. B., Manatt, S. L., Wood, C. S.

Technical Report No. 32-857 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 23, December 1965, pp. 5433-5438)

For abstract, see Entry M04.

M09 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS

Ingham, J. D., Lawson, D. D., Manatt, S. L.

Rapp, N. S., Hardy, J. P.

Technical Report No. 32-904 (Unclassified)

(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75-91)

For abstract, see Entry I03.

M10 CHARACTERIZATION OF FUNCTIONAL GROUPS BY NUCLEAR MAGNETIC RESONANCE.

I. CLASSIFICATION OF ALCOHOLS FROM THE FLUORINE-19 SPECTRA OF TRIFLUOROACETATES

Manatt, S. L.

Technical Report No. 32-930 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 88, pp. 1323-1324, 1966)

This Report intends to describe an nmr scheme for classification of hydroxyl compounds in a more reliable and informative manner than other recently described nmr techniques.

The study of the ^{19}F nmr spectra of the trifluoroacetate (TFA) esters of a large number of alcohols revealed that the TFA groups give sharp ^{19}F signals and that the order of shielding is always primary < secondary < tertiary. The method described here has certain advantages. With this method, one is looking at the signal from three ^{19}F nuclei vs one ^1H nucleus which can be a multiplet. Because one observes the ^{19}F spectrum, signals from the other protons in the molecules of interest are far removed and the restrictions on the choice of solvent are removed.

Marsh, H. E., Jr.

- M11 STERILIZED SOLID-PROPELLANT ROCKET MOTORS FOR MARS LANDING MISSIONS (REVISION 1)**
 Montgomery, L. C., Marsh, H. E., Jr.
 Technical Report No. 32-725, June 30, 1965
 (Unclassified)

For abstract, see Entry M30.

Marshall, R. R.

- M12 POLYMINERALIC INCLUSIONS IN THE ODESSA IRON METEORITE**
 Marshall, R. R., Keil, K.
 Technical Report No. 32-807 (Unclassified)
 (Reprinted from *Icarus: International Journal of the Solar System*, Vol. 4, No. 5/6, December 1965, pp. 461-479)

A piece of the Odessa iron meteorite (a coarse octahedrite) was found to contain two types of nodules: globular and elongated ones. The globular nodules have a core of troilite surrounded by a shell of graphite and/or fine-grained graphite-troilite mixture containing some daubréelite, and a thin outer layer of schreibersite and cohenite, in some cases with further localization of schreibersite and cohenite to one side. The relative proportions of the troilite and the intimate mixture of graphite and troilite vary greatly. The mineral content of the elongated nodules is more complex; they consist of troilite, graphite, schreibersite, cohenite, forsterite, calcium-rich chromian clinopyroxene, enstatite, albite, chlorapatite, and daubréelite (listed in the approximate order of their abundances by volume). Magnetite and its small inclusions of nickel-rich iron are probably terrestrial alteration products. Again, schreibersite and cohenite are frequently concentrated on the same side of the elongated nodules. The compositions of the silicates, magnetite, chlorapatite, nickel-rich iron, and daubréelite were measured by electron microprobe techniques. Plots of the small contents of iron in a number of olivine and pyroxene grains show ranges in composition that are narrow but that are outside the limits of uncertainty in the measurements. The consistent elongation in one direction of the nodules containing silicates may be interpreted as the result of solidification of the meteorite under the influence of a gravitational field and/or convection.

Marte, J. E.

- M13 AN EXPERIMENTAL STUDY OF THE FLOW FIELD PRODUCED BY THREE HYPERSONIC JETS IMPINGING ON A SURFACE IN A VACUUM ENVIRONMENT**
 Marte, J. E., Fox, N. L.
 Technical Memorandum No. 33-231, July 30, 1965
 (Unclassified)

A tuft study to investigate interference phenomena between three jet plumes which impinge on a nearby normal surface was carried out in the Jet Propulsion Laboratory's 25-ft space simulator. The existence of reverse flow in the triangular central region which was interior to three *Surveyor*-type vernier motors was established. Under certain conditions the reverse flow might provide a mechanism for the transport of surface dust into the central portion of the *Surveyor* vehicle. A pressure measurement was made in the plane of the nozzle exits on the vehicle centerline at a nozzle-plate height of 4.5-ft full scale. At this point the dynamic pressure in the reverse flow was 30 per cent of the dynamic pressure at the plate on the nozzle centerlines.

Martin, D. P.

- M14 THE HIGH-ALTITUDE ROCKET RADAR PROJECT**
 Brown, W. E., Jr., Barath, F. T., Jordan, R. L., Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
 Technical Memorandum No. 33-196, June 15, 1965
 (Unclassified)

For abstract, see Entry B30.

Masek, T. D.

- M15 PLASMA NONUNIFORMITY AND GRID EROSION IN AN ELECTRON BOMBARDMENT ION ENGINE**
 Kerrisk, D. J., Masek, T. D.
 Technical Report No. 32-738 (Unclassified)
 (Reprinted from the *AIAA Journal*, Vol. 3, No. 6, June 1965, pp. 1060-1066)

For abstract, see Entry K11.

Mattson, R. F.

- M16 DEVELOPMENT OF THE RANGER BLOCK III SPACECRAFT PROPULSION SYSTEM**
 Evans, D. D., Groudle, T. A., Mattson, R. F.
 Technical Report No. 32-829, March 15, 1966
 (Unclassified)

For abstract, see Entry E09.

Maxworthy, T.

- M17 AN EXPERIMENTAL DETERMINATION OF THE SLOW MOTION OF A SPHERE IN A ROTATING, VISCOUS FLUID**
 Maxworthy, T.
 Technical Report No. 32-601 (Unclassified)

(Reprinted from *Journal of Fluid Mechanics*, Vol. 23, No. 2, 1965, pp. 373-384)

The drag of a sphere has been measured as it moves along the axis of a rotating, viscous fluid. Rotation has been found to modify the classical low-Reynolds-number flow so that the drag is increased and the effects of the finite Reynolds number, R , and of wall proximity are reduced as the rotation parameter, the Taylor number T , increases. The results confirm the theory of Childress when both Reynolds number and Taylor number are small. The rate at which the sphere rotates with respect to the rotating fluid frame has also been measured and was found to be less than the values calculated by Childress for small T and R , but to approach the theoretical values in a reasonable way.

M18 ACCURATE MEASUREMENTS OF SPHERE DRAG AT LOW REYNOLDS NUMBERS

Maxworthy, T.

Technical Report No. 32-784 (Unclassified)

(Reprinted from *Journal of Fluid Mechanics*, Vol. 23, Part 2, 1965, pp. 369-373)

An accurate measurement of low-Reynolds number sphere drag has been made. Some of the inaccuracies of previous measurements are revealed. Comparison with the theoretical studies shows that the Oseen formula is as accurate as any in predicting sphere drag below a Reynolds number of 0.4.

McDade, J. J.

M19 EXPERIMENTAL ASSEMBLY AND STERILIZATION LABORATORY (EASL) OPERATIONS: PHASE I

Kapell, G. F., McDade, J. J., Gavin, T. R.

Technical Report No. 32-941, April 15, 1966
(Unclassified)

For abstract, see Entry K02.

Meisenholder, G. W.

M20 A PRACTICAL METHOD FOR SENSOR ABSOLUTE CALIBRATION

Meisenholder, G. W.

Technical Report No. 32-913 (Unclassified)

(Reprinted from *Applied Optics*, Vol. 5, No. 4, April 1966, pp. 533-536)

This paper describes a method of performing sensor calibrations using an NBS standard of spectral irradiance. The method shown, among others, was used for calibration of the *Mariner IV* Canopus sensor. Agreements of inflight response to preflight calibrations performed by this technique have been found to be well within 10%.

Menard, W. A.

M21 EXPERIMENTAL MEASUREMENTS OF NON-EQUILIBRIUM AND EQUILIBRIUM RADIATION FROM PLANETARY ATMOSPHERES

Thomas, G. M., Menard, W. A.

Technical Report No. 32-902 (Unclassified)

(Reprinted from *AIAA Journal*, Vol. 4, No. 2, February 1966, pp. 227-237)

For abstract, see Entry T06.

M22 MEASUREMENT OF THE THERMAL CONDUCTIVITY OF NOBLE GASES IN THE TEMPERATURE RANGE 1500 TO 5000 deg KELVIN

Collins, D. J., Menard, W. A.

Technical Report No. 32-903 (Unclassified)

(Reprinted from *Journal of Heat Transfer, Transactions of the ASME*, February 1966, pp. 52-56)

For abstract, see Entry C16.

Merrick, W. D.

M23 LARGE ANTENNA APERTURES AND ARRAYS FOR DEEP SPACE COMMUNICATIONS

Potter, P. D., Merrick, W. D., Ludwig, A. C.

Technical Report No. 32-848, November 1, 1965
(Unclassified)

For abstract, see Entry P11.

Miller, L. W.

M24 ATLAS-CENTAUR VI FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA

Miller, L. W., et al.

Technical Report No. 32-911, April 15, 1966
(Unclassified)

This Report describes the best current estimate of the *Atlas-Centaur VI* (A/C-6) spacecraft flight path and the way in which the flight path was obtained. This document also includes orbit determination program (ODP) printout data facsimiles.

Miller, R. B.

M25 SPACECRAFT VISIBILITY PROGRAM WITH CONTOUR PLOTTER

Miller, R. B.

Technical Memorandum No. 33-273, March 1, 1966
(Unclassified)

The spacecraft visibility program has two prime objectives: (1) to produce visibility contour plots of all existing DSIF antennas, and (2) to produce visibility contour plots of any antenna configuration at any location in the world to aid in evaluation of proposed antennas and station locations.

The program was developed for the SDS 930 computer of systems data analysis group located at the Goldstone Echo station. It uses a Benson-Lehner Electro-plotter that has been converted to on-line. The program can be used on other computers because it is written in FORTRAN II, and can easily be adapted for use with other plotters.

Minovitch, M.

M26 UTILIZING LARGE PLANETARY PERTURBATIONS FOR THE DESIGN OF DEEP-SPACE, SOLAR-PROBE, AND OUT-OF-ECLIPTIC TRAJECTORIES

Minovitch, M.

Technical Report No. 32-849, November 15, 1965
(Unclassified)

This Report is concerned with three types of free-fall missions that are primarily designed for unmanned vehicles, viz. deep space, solar probe, and out-of-ecliptic missions. The energies required to attain these trajectories are beyond the present direct-transfer capability using available boosters. Solar-impact and 90-deg-inclination trajectories require launch energies so high that second-generation nuclear upper stages or ion engines would be necessary. By utilizing large planetary perturbations, it is possible that a rocket like *Titan II-Centaur* with an extra kick stage can, by sacrificing a few extra pounds for planetary approach guidance, obtain trajectories that a *nuclear Saturn V* cannot obtain.

Moacanin, J.

M27 OUTGASSING RATES IN POLYMERIC FOAMS

Cuddihy, E. F., Moacanin, J.

Technical Report No. 32-840, December 15, 1965
(Unclassified)

For abstract, see Entry C19.

M28 ELECTRON TRANSFER TO VINYLAROMATIC POLYMERS

Rembaum, A., Moacanin, J.

Technical Report No. 32-791 (Unclassified)
(Reprinted from *Exchange Reaction, International Atomic Energy Agency*, Vienna, 1965, pp. 173-190)

For abstract, see Entry R09.

M29 EXPERIMENTAL PROCEDURES FOR MOLECULAR WEIGHT DETERMINATION BY LIGHT SCATTERING

Beattie, W. H., Laudenslager, R. K., Moacanin, J.

Technical Memorandum No. 33-242, January 1, 1966
(Unclassified)

For abstract, see Entry B09.

Montgomery, L. C.

M30 STERILIZED SOLID-PROPELLANT ROCKET MOTORS FOR MARS LANDING MISSIONS (REVISION 1)

Montgomery, L. C., Marsh, H. E., Jr.

Technical Report No. 32-725, June 30, 1965
(Unclassified)

A description is given of the chemical approach taken in the initial phase of the program to develop a sterile solid-propellant motor for the planetary and lunar landings. The current objectives which require the heat-sterilization approach and the ultimate test criterion for heat sterilizability of a spacecraft component are considered. The significant crusting of the pro-

pellants, and its related physical effects are evaluated. The development of propellants for heat-sterilization application is described.

Muhleman, D. O.

M31 A REVIEW OF RADAR ASTRONOMY—PARTS I, II

Muhleman, D. O., Goldstein, R., Carpenter, R.

Technical Report No. 32-824 (Unclassified)
(Reprinted from *IEEE Spectrum*, Vol. 2, No. 10, October 1965, pp. 44-55 and Vol. 2, No. 11, November 1965, pp. 78-89)

The past few years have seen spectacular advances in the science of radar astronomy. This two-part article develops fundamental concepts and equations, describes new measuring techniques, and summarizes significant results from planetary and lunar radar experiments.

In the conclusion of this article the rotational and surface characteristics of several planets, particularly Venus, are considered. Most of the immediate future research will involve the Moon, Mercury, Venus, and Mars.

Narasimha, R.

N01 EXACT NUMERICAL SOLUTION OF THE COMPLETE BGK EQUATION FOR STRONG SHOCK WAVES

Chahine, M. T., Narasimha, R.

Technical Report No. 32-671 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics*, Vol. 1, Sec. 2, 1965, pp. 140-160)

For abstract, see Entry C06.

Nash, D. B.

N02 A LUNAR X-RAY DIFFRACTION EXPERIMENT

Speed, R. C., Nash, D. B., Nickle, N. L.

Technical Report No. 32-756 (Unclassified)
(Reprinted from *Advances in X-Ray Analysis*, Vol. 8, Plenum Press, 1965, pp. 400-419)

For abstract, see Entry S23.

N03 THE UTILITY OF UNMANNED PROBES IN LUNAR SCIENTIFIC EXPLORATION

Speed, R. C., Nash, D. B., Adams, J. B.

Technical Memorandum No. 33-241, July 15, 1965
(Unclassified)

For abstract, see Entry S25.

Nathan, R.

N04 DIGITAL VIDEO-DATA HANDLING

Nathan, R.

Technical Report No. 32-877, January 5, 1966
(Unclassified)

A technique has been developed which makes it possible to perform accurate, detailed operations and analyses upon digitized pictorial data. Television pictures transmitted from the *Ranger* and *Mariner* spacecraft have been significantly im-

proved in clarity by correcting those system distortions which affect photometric, geometric, and frequency fidelity. Various classes of structured noise have also been detected and removed digitally by means of newly devised two-dimensional filters. Although mathematically the filters are easier to describe in the frequency domain, they are more effectively applied as a convolution operation on the original digitized photographs. The cleaned-up, enhanced pictures are then used by the computer for further interpretive and statistical analyses.

Nerheim, N. M.

N05 ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE EXHAUST OF A MPD SOURCE

Kelly, A. J., Nerheim, N. M., Gardner, J. A.
Technical Report No. 32-796, September 15, 1965
(Unclassified)

For abstract, see Entry K06.

Nickle, N. L.

N06 A LUNAR X-RAY DIFFRACTION EXPERIMENT

Speed, R. C., Nash, D. B., Nickle, N. L.
Technical Report No. 32-756 (Unclassified)
(Reprinted from *Advances in X-Ray Analysis*, Vol. 8,
Plenum Press, 1965, pp. 400-419)

For abstract, see Entry S23.

Ostrum, G. K.

O01 ORGANIC SYNTHESIS USING FUSED SALT SYSTEMS: PREPARATION OF A POLYTRIPHENYLENE

Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

The synthesis of polybenzenes has received considerable attention because of the desirable thermal stability of these polymers. It has been pointed out that chain branching could occur during the polymerization of benzene with Lewis acid catalyst-oxidant, but the presence or absence of such branching has not yet been conclusively shown. If such branching occurs, cyclization to produce a triphenylene nucleus in the polymer chain could occur by the same mechanism proposed for chain growth. Therefore, as part of the study of the preparation and characterization of high-temperature polymers using fused salts as reaction media, a polytriphenylene has been prepared using a eutectic mixture of ferric chloride (60 wt%), sodium chloride (26 wt%), and potassium chloride (14 wt%) both as "solvent" and source of Lewis acid.

Petty, S. M.

P01 A PRECISION DC-POTENTIOMETER MICROWAVE INSERTION-LOSS TEST SET

Stelzried, C. T., Reid, M. S., Petty, S. M.
Technical Report No. 32-887, March 15, 1966
(Unclassified)

For abstract, see Entry S28.

Peyret, R.

P02 SUB-ALFVÉNIC FLOW IN A DUCT WITH A NONUNIFORM MAGNETIC FIELD

Peyret, R.
Technical Report No. 32-871, April 15, 1966
(Unclassified)

The flow of a conducting fluid in a duct through a nonuniform magnetic field of the following type is considered: for $x < 0$, the field is uniform and parallel to the axis Ox of the duct; for $x > 0$, the field is nonuniform and the magnetic lines are slightly curved, so that it is possible to use a small-perturbation theory. Moreover, the magnetic Reynolds number R_m and the Alfvén number A are assumed small. One calculates the flow field, then the induced magnetic field. It is found that the disturbances which are propagated upstream decay exponentially for the flow and algebraically for the magnetic field.

Phillips, W.

P03 REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS.

VOLUME I. GENERAL
Davis, J. P., Gronroos, H., Phillips, W.
Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

For abstract, see Entry D02.

Pickering, W. H.

P04 MARINER IV MISSION TO MARS (PART II)

Pickering, W. H., et al.
Technical Report No. 32-782 (Unclassified)
(Reprinted from *Astronautics and Aeronautics*, Vol. 3,
No. 10, October 1965, pp. 20-43)

This two-part Technical Report is a series of individual papers documenting the *Mariner-Mars* project. Part I, which has been previously published, detailed the pre-encounter data on design, development and testing of *Mariner IV*, as well as papers detailing methods of communication with and obtaining data from the spacecraft during flight.

Part II, which consists of post-encounter data, is a documentation of events which took place during the *Mariner IV*'s encounter with Mars and whatever took place subsequently: *Mariner's* flight to Mars, scientific exploration, maintaining thermal control, maneuver and attitude control, and *Mariner IV* timing and sequencing.

Pivrotto, T. J.

P05 SIMILARITY IN CONFINED VORTEX FLOWS

Roschke, E. J., Pivrotto, T. J.
Technical Report No. 32-789, August 15, 1965
(Unclassified)

For abstract, see Entry R24.

P06 AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF CONCENTRATION RATIO DISTRIBUTIONS IN A BINARY COMPRESSIBLE VORTEX FLOW

Pivrotto, T. J.

Technical Report No. 32-808, March 15, 1966

(Unclassified)

A scheme for containing fissionable material in the gas phase in a gaseous-core, nuclear-reactor propulsion system is considered. The results of a referenced analysis of this concept indicate that a rotating annular cloud of highly concentrated fuel gas can be retained in a steady, two-dimensional, potential vortex flow.

The primary objective was to experimentally determine whether a real vortex flow can sustain an annular cloud of a high-molecular-weight gas at room temperature and to determine analytically and experimentally how this cloud is influenced by several of the flow parameters.

Qualitative agreement between the theoretical radial distributions of the heavy to light gas mass density ratio and the measured distributions was found. The maximum enrichment factor was found experimentally to increase as the heavy gas mass flow rate was decreased at each of three hydrogen mass flow rates tested. This behavior of the maximum enrichment factor was also found for the analytical model. From the analysis based on a two-dimensional potential vortex flow, a critical light gas mass flow rate, with respect to achieving large maximum enrichment factors, was found.

P07 MASS-RETENTION MEASUREMENTS IN A BINARY COMPRESSIBLE VORTEX FLOW

Pivrotto, T. J.

Technical Report No. 32-864, June 15, 1966

(Unclassified)

Confined binary vortex flow fields have been proposed as gaseous-fuel-retention devices for gas-core nuclear reactors. Several such flows have been evaluated in this investigation by measuring the mass flow rate of heavy gas discharging from the vortex tube. Hydrogen and nitrogen were used to generate the vortex flow fields and Freon-13 was used for the heavy gas. An infrared photometer operating at a wavelength of approximately 8.3μ was developed and used to measure the transient decay of the discharge rate of Freon after an abrupt cutoff of Freon inlet flow. From these measurements the average residence time of the Freon particles in several vortex-tube configurations for several mass flow rates of Freon and hydrogen or nitrogen were determined. The conclusion reached from the results of this investigation was that these particular vortex flow fields do not retain significantly more Freon than would be contained in the same device and under the same conditions of pressure and temperature if no diffusion occurred between the light and heavy species.

Porter, R. N.

P08 ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT

Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.

Technical Report No. 32-735, July 15, 1965

(Unclassified)

For abstract, see Entry D05.

P09 THE FABRICATION OF SEAMLESS TEFLON PROPELLANT EXPULSION BLADDERS

Porter, R. N.

Technical Report No. 32-914, April 14, 1966

(Unclassified)

Seamless Teflon bladders of TFE, FEP, or a combination of both are fabricated by several firms for the NASA space program. The process involves mixing aqueous dispersions of Teflon particles, spraying this dispersion onto a metal mandrel, sintering the particles into a film and then etching out the metal mandrel. Teflon bladders made in this manner are reasonably compatible with propellants and capable of repeatedly expelling propellants, but they are somewhat permeable to propellants. Production of defect-free bladders requires a concerted quality control program to monitor every step in the process.

Posner, E. C.

P10 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES

Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,

Posner, E. C.

Technical Report No. 32-772, December 1, 1965

(Unclassified)

For abstract, see Entry A08.

Potter, P. D.

P11 LARGE ANTENNA APERTURES AND ARRAYS FOR DEEP SPACE COMMUNICATIONS

Potter, P. D., Merrick, W. D., Ludwig, A. C.

Technical Report No. 32-848, November 1, 1965

(Unclassified)

These considerations relating to antennas for deep space communications are treated in detail: (1) the economic balance between large ground antenna apertures and potential spacecraft improvements, (2) the best method of implementing large apertures as a function of size, and (3) the optimum frequency of operation. Report concentrates on economics, because there does not appear to be any serious technical problem. Three conclusions are firmly established: (1) equivalent apertures, large compared with that of a 200-ft-D class paraboloid, are very expensive; (2) either a steerable paraboloid of approximately 200-ft D or an array of these antennas is the ideal type of aperture implementation; and (3) within the present state of the art in structural design the optimum frequency of operation is approximately 2 Gc/s.

Poynter, R. L.

- P12 MICROWAVE SPECTRUM, STRUCTURE, AND DIPOLE MOMENT OF 2,4-DICARBAHEPTABORANE (7)**
Beaudet, R. A., Poynter, R. L.
Technical Report No. 32-823 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 7, October 1965, pp. 2166-2170)

For abstract, see Entry B10.

Primack, J. R.

- P13 TEMPERATURE RELAXATION IN A FULLY IONIZED PLASMA**
Wu, C.-S., Klevans, E. H., Primack, J. R.
Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 6, June 1965, pp. 1126-1133)

For abstract, see Entry W32.

Prislin, R. H.

- P14 EFFECT OF BOUNDARY-LAYER TRANSITION ON DYNAMIC STABILITY**
Jaffe, P., Prislin, R. H.
Technical Report No. 32-841 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 3, No. 1, January 1966, pp. 46-52)

For abstract, see Entry J04.

- P15 FREE-FLIGHT AND FREE-OSCILLATION TECHNIQUES FOR WIND-TUNNEL DYNAMIC-STABILITY TESTING**
Prislin, R. H.
Technical Report No. 32-878, March 1, 1966
(Unclassified)

This Report presents the fundamentals of two wind-tunnel dynamic-stability testing techniques employed at the Jet Propulsion Laboratory: the free-flight technique, and the sting-supported free-oscillation technique. The techniques are described with reference to testing a body of revolution exhibiting planar motion. Emphasis is put on the data-reduction problem which arises when one considers nonlinear aerodynamic coefficients at arbitrary angles of attack. An approach to a general nonlinear case is outlined, and a detailed analysis is carried out for a cubic pitching-moment curve and arbitrary lift and drag curves. In addition, the advantages and disadvantages of utilizing the alternate testing methods are discussed. Possible extensions of both techniques into additional dynamic-stability testing areas are mentioned.

Randolph, J. E.

- R01 PYROTECHNIC SHOCK ANALYSIS AND TESTING METHODS**
Hoffman, A. R., Randolph, J. E.
Technical Memorandum No. 33-270, February 15, 1966
(Unclassified)

For abstract, see Entry H19.

- R02 MARINER-MARS 1964 FLIGHT DYNAMIC DATA**
Randolph, J. E.
Technical Memorandum No. 33-278, May 15, 1966
(Unclassified)

This Memorandum presents an analysis of the dynamic flight environment of the *Mariner-Mars* 1964 spacecraft. The reduced data from *Mariner III* and *Mariner IV* are presented and compared. Nine environmental measurements were taken for each spacecraft. These consisted of five vibration transducers within the payload area of each launch vehicle and four microphones mounted outside the vehicle on the launch complex umbilical tower. These telemetered and recorded data have been analyzed using the following techniques: oscillograms, bandpass, power spectra, shock spectra, and data compression. The reduced data are discussed with reference to each appropriate analysis technique. No comparison with ground test data is made.

Raper, O. F.

- R03 PRIMARY PROCESSES IN OZONE PHOTOLYSIS**
DeMore, W. B., Raper, O. F.
Technical Report No. 32-906 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 44, No. 5, March 1966, pp. 1780-1783)

For abstract, see Entry D03.

Rapp, N. S.

- R04 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES. DETERMINATION OF THE CARBON-14 DISTRIBUTION IN THE ISOCYANATE GROUPS OF 2,4-TOLYLENE DIISOCYANATE**
Kopka, E. F., Rapp, N. S., Ingham, J. D.
Technical Report No. 32-861 (Unclassified)
(Reprinted from the *Journal of Labeled Compounds*, Vol. 1, No. 3, July-September 1965, pp. 1-12)

For abstract, see Entry K21.

- R05 THE MECHANISM OF THERMAL DEGRADATION OF CERTAIN POLYETHER-POLYURETHANS**
Ingham, J. D., Rapp, N. S.
Technical Report No. 32-880 (Unclassified)
(Reprinted from *Polymer Engineering and Science*, Vol. 6, No. 1, January 1966, pp. 1-6)

For abstract, see Entry I02.

- R06 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS**
Ingham, J. D., Lawson, D. D., Manatt, S. L., Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75-91)

For abstract, see Entry I03.

Reid, M. S.

R07 A PRECISION DC-POTENTIOMETER MICROWAVE INSERTION-LOSS TEST SET

Stelzried, C. T., Reid, M. S., Petty, S. M.

Technical Report No. 32-887, March 15, 1966

(Unclassified)

For abstract, see Entry S28.

Rembaum, A.

R08 EQUILIBRIA BETWEEN METALLIC SODIUM AND AROMATIC HYDROCARBONS

Rembaum, A., Eisenberg, A., Haack, R.

Technical Report No. 32-765 (Unclassified)

(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2291-2292)

This short communication gives a summary of the preliminary results of a quantitative study of the equilibria between sodium and some substituted aromatic hydrocarbons by a spectrophotometric technique.

R09 ELECTRON TRANSFER TO VINYLAROMATIC POLYMERS

Rembaum, A., Moacanin, J.

Technical Report No. 32-791 (Unclassified)

(Reprinted from *Exchange Reaction, International Atomic Energy Agency*, Vienna, 1965, pp. 173-190)

Aromatic polymers accept electrons from alkali metals to form polyradical anions. These undergo chain scission as a result of electronic interaction between aromatic rings. Spectrophotometric and chemical evidence led to the conclusion that during the chain-breaking process polymeric fragments were formed which had the properties of "living polymers," i.e., the characteristic visible spectra and the capability of initiating the polymerization of a number of vinyl monomers. It was possible to follow the rate of chain scission in the case of poly(4-vinyl biphenyl) and poly(α -vinyl naphthalene) by means of viscosity and spectrophotometric measurements. The postulated mechanism was found to be consistent with the slow decrease in free spin concentration measured by means of the electron spin resonance technique. Chain scission in polyacenaphthalene takes place at a much faster rate than in poly(4-vinyl biphenyl) and this fact is in good agreement with simple LCAO MO calculations. Preliminary experiments indicate that electron transfer to poly-N-vinyl carbazole produces little if any degradation. These investigations led to the examination of the temperature effect on the electron-transfer reaction from sodium to some substituted aromatic hydrocarbons. The details of this effect are discussed.

Renzetti, N. A.

R10 TRACKING AND DATA ACQUISITION SUPPORT FOR THE MARINER-VENUS 1962 MISSION

Renzetti, N. A.

Technical Memorandum No. 33-212, July 1, 1965

(Unclassified)

This document summarizes the technical activities of the Deep Space Instrumentation Facility in support of the *Mariner II* mission. It includes a synopsis of the mission, a comprehensive account of the tracking operations, and a performance evaluation. The tracking and data acquisition support are also delineated, and a complete list of reference material is given.

R11 TRACKING AND DATA ACQUISITION REPORT: MARINER-MARS 1964 MISSION.

VOLUME I. NEAR-EARTH TRAJECTORY PHASE

Renzetti, N. A.

Technical Memorandum No. 33-239, January 1, 1965

(Unclassified)

This document summarizes the technical activities of the AFETR, certain stations of the NASA/GSFC Manned Space Flight Network (MSFN) and Satellite Tracking and Data Acquisition Network (STADAN), and the NASA/JPL Deep Space Network (DSN) in support of the near-Earth trajectory phase of the *Mariner-Mars* 1964 Mission. Included in this document are the tracking and data acquisition requirements and related support plans for all the participating agencies, a comprehensive account of the tracking operations, and a performance evaluation summary.

Richard, R. J.

R12 EARTH-MOON TRAJECTORIES, 1960-70

Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.

Technical Report No. 32-503 (Rev. 1), September 15, 1965

(Unclassified)

This Report gives key characteristics of Earth-to-Moon trajectories for the period 1965-1970. It is intended to provide trajectory analysts with data, in volume, so that they may perform preliminary design studies and conduct investigations of the properties of ballistic lunar trajectories. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purpose. The data presented assumed launch to occur at Cape Kennedy, arrival to occur when the Moon is over the meridian of the DSIF tracking station at Goldstone, California, and the flight time to be between 2 and 3 days. An explanation of the analytical model used in the generation of the data, and detailed equations, are presented.

R13 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part A

June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964-1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in

2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R14 EARTH–MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part B
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R15 EARTH–MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part C
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–

1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R16 EARTH–MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part D
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R17 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. V, Part A

June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964-1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6-August 10; Flight time range (days), 70-280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth-Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R18 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. V, Part B

June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964-1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6-August 10; Flight time range (days), 70-280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth-Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit

determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R19 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. V, Part C

June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964-1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than $40 \text{ km}^2/\text{sec}^2$ are included).

Launch date (1971), March 6-August 10; Flight time range (days), 70-280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth-Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

Rindfleisch, T.

R20 A FIGURE OF MERIT MEASURING PICTURE RESOLUTION

Rindfleisch, T., Willingham, D.

Technical Report No. 32-666, September 1, 1965

(Unclassified)

In order to optimize the quality of data obtained from lunar and planetary photographic missions, a general and versatile resolution measure is needed that accounts for the numerous degrading factors inherent in the facsimile system. A mathematical formalism is developed which leads to a single number or figure of merit measuring a characteristic dimension of the smallest detectable object in a picture of an extended complex scene. The formalism is in modular form and can include the effects on the system resolution due to statistical and photometric properties of the surface being viewed, atmospheric turbulence, image motion, characteristics of the television and recording system, system noises, and properties of the human observer.

The treatment is unified within the framework of linear system analysis and assumes that portions of the transfer

process act as spatial filters and that the human observer functions as a signal-to-noise optimizing low-pass filter. The contrast present in the object scene is determined by the statistical and photometric properties of the scene. A comparison of the figure of merit to conventional resolution measures is made, indicating its advantages for system design and performance evaluation over the conventional engineering comparison techniques, which do not predict absolute performance.

R21 A PHOTOMETRIC METHOD FOR DERIVING LUNAR TOPOGRAPHIC INFORMATION

Rindfleisch, T.

Technical Report No. 32-786, September 15, 1965

(Unclassified)

A general and rigorous treatment is given of the photometric method for deriving lunar surface elevation information from pictures of the surface. In the course of the derivation certain shortcomings inherent in the method are pointed out. The resulting equations are then applied to the *Ranger* pictures as part of a digital processing procedure and examples are given.

Rodemich, E. R.

R22 THE VARIANCE OF SPECTRAL ESTIMATES

Rodemich, E. R.

Technical Report No. 32-892, March 31, 1966

(Unclassified)

In this Report the main result proved is a generalization of a formula of Goldstein who showed that if the estimate $S(\omega)$ for the spectral density is computed by the use of the function $y(x) = \text{sgn}(x)$, and if the spectrum is flat, then the dominant term in the variance of $S(\omega)$ is $\frac{1}{2} \pi^2 K/N$. Theorem 3 evaluates this term for non-flat spectra and for more general functions $y(x)$.

This analysis shows that the loss in accuracy caused by working with $y(x)$ instead of with x itself can be decreased considerably by using, for $y(x)$, a step function with more than two values.

Rogero, R. S.

R23 EXPERIMENTAL MEASUREMENTS ON A ROTATING DETONATION-LIKE WAVE OBSERVED DURING LIQUID ROCKET RESONANT COMBUSTION

Clayton, R. M., Rogero, R. S.

Technical Report No. 32-788, August 15, 1965

(Unclassified)

For abstract, see Entry C14.

Roschke, E. J.

R24 SIMILARITY IN CONFINED VORTEX FLOWS

Roschke, E. J., Pivrotto, T. J.

Technical Report No. 32-789, August 15, 1965

(Unclassified)

Results of an experimental investigation designed to test a simplified theory for obtaining dynamic similarity in confined vortex flows are presented. The simplified model from which similarity is obtained consists of the vortex flow of dissimilar fluids under conditions of exact geometric similarity. Steady, laminar, viscous, compressible flow in a two-dimensional, axisymmetric vortex is considered. The experiment consists of end-wall pressure measurements using the two diatomic gases, nitrogen and hydrogen, in identically the same vortex apparatus. The results of this investigation tend to show that simplified theories of vortex flow are insufficient, but the degree or precise manner of their defect cannot be delineated.

Examination of another set of data using the identical vortex apparatus disclosed that dynamic similarity in static-pressure distributions between tests using nitrogen and hydrogen could be closely approached by conducting the tests at equal values of static pressure at the cylindrical wall. Some of the latter results are presented and discussed.

Roth, R. Y.

R25 DESIGN PARAMETERS FOR BALLISTIC INTER-PLANETARY TRAJECTORIES. PART II. ONE-WAY TRANSFERS TO MERCURY AND JUPITER

Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.

Technical Report No. 32-77, January 15, 1966

(Unclassified)

For abstract, see Entry C10.

R26 EARTH-MOON TRAJECTORIES, 1960-70

Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirchofer, W. E.

Technical Report No. 32-503 (Rev. 1), September 15, 1965

(Unclassified)

For abstract, see Entry R12.

R27 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part A

June 15, 1965 (Unclassified)

For abstract, see Entry R13.

R28 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part B

June 15, 1965 (Unclassified)

For abstract, see Entry R14.

R29 EARTH-MARS TRAJECTORIES, 1971

Richard, R. J., Roth, R. Y.

Technical Memorandum No. 33-100, Vol. IV, Part C

June 15, 1965 (Unclassified)

For abstract, see Entry R15.

- R30 EARTH-MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part D
June 15, 1965 (Unclassified)

For abstract, see Entry R16.

- R31 EARTH-MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part A
June 15, 1965 (Unclassified)

For abstract, see Entry R17.

- R32 EARTH-MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part B
June 15, 1965 (Unclassified)

For abstract, see Entry R18.

- R33 EARTH-MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part C
June 15, 1965 (Unclassified)

For abstract, see Entry R19.

Rowley, R. W.

- R34 THE EFFECT OF INJECTOR DESIGN ON
THRUST-CHAMBER EROSION
Rowley, R. W., Tyler, W. H.
Technical Report No. 32-750, March 1, 1966
(Unclassified)

Results are presented for an experimental investigation of the relationship between injector design and the erosion of ablative and pyrolytic graphite thrust-chamber throats. Techniques used to determine spray properties and local heat flux are described. It is concluded that injector spray properties, including local mass and mixture-ratio distributions, significantly influence throat erosion, and that proper control of these spray properties can reduce such erosion without recourse to separate film-cooling orifices. Four injectors, each incorporating 10 unlike-impinging-doublet elements, were tested with N_2O_4 - N_2H_4 propellants at the 100-lb thrust level. Three different arrangements of the elements were used, one of which demonstrated substantially lower erosion of both ablative and pyrolytic graphite materials. Erosion of pyrolytic graphite, which occurred primarily in regions of high local mixture ratio, can be controlled by proper use of the variation in local mixture ratio observed within the injector spray. Erosion of Refrasil-phenolic occurred primarily in regions of high local heat transfer, but was also affected by the local mixture ratio. Although changing the spray configuration in the boundary flow reduced erosion of the ablative material, the relationship between spray properties and heat transfer or ablation has not been clearly defined.

Rupe, J. H.

- R35 AN EXPERIMENTAL CORRELATION OF THE NON-
REACTIVE PROPERTIES OF INJECTION SCHEMES
AND COMBUSTION EFFECTS IN A LIQUID-
PROPELLANT ROCKET ENGINE.
PART I. THE APPLICATION OF NONREACTIVE-
SPRAY PROPERTIES TO ROCKET-MOTOR
INJECTION DESIGN
Rupe, J. H.
Technical Report No. 32-255, July 15, 1965
(Unclassified)

The properties of the sprays produced by a pair of unlike impinging streams of nonreactive fluids were utilized as the design basis for a series of eight injectors having distinctively different specifications. Particular emphasis was placed on the use of available information and the development of new techniques, where required, to permit quantitative description of the mass and mixture-ratio distributions produced by each injection scheme. Methods of describing the mass-distribution model of an element are presented in detail, together with the properties of injector orifices, the jets they produce, and the combined flows provided by each injector. This information is being utilized as a basis for correlating injection schemes with combustion phenomena.

- R36 AN EXPERIMENTAL CORRELATION OF THE NON-
REACTIVE PROPERTIES OF INJECTION SCHEMES
AND COMBUSTION EFFECTS IN A LIQUID-
PROPELLANT ROCKET ENGINE.
PART VI. THE RELATION BETWEEN THE
STARTING TRANSIENT AND INJECTION
HYDRAULICS
Clayton, R. M., Rupe, J. H.
Technical Report No. 32-255, October 29, 1965
(Unclassified)

For abstract, see Entry C13.

- R37 ON THE EVOLUTION OF ADVANCED PROPULSION
SYSTEMS FOR SPACECRAFT
Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.
Technical Report No. 32-735, July 15, 1965
(Unclassified)

For abstract, see Entry D05.

Russell, D. A.

- R38 ELECTRON-BEAM MEASUREMENTS OF
SHOCK-WAVE THICKNESS
Russell, D. A.
Technical Report No. 32-751 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics*, Vol. 1, 1965,
pp. 265-276)

Shock-wave density profiles have been measured in the GASCIT 17-in. shock tube in argon and helium at Mach numbers between 2 and 8. A 5-15 kv electron beam was injected into the shock tube through a needle and collected by

a small Faraday cage. The change in cage current was monitored as the shock wave passed the measuring station, and this change was related to the density profile. Maximum-slope shock thicknesses were found to be consistently thinner than the mean of the experimental data of Camac. The measurements are shown to deviate from the Navier-Stokes predictions and to fall between the bimodal model and the BGK model of Liepmann et al.

Saffren, M. M.

- S01 SUPERCONDUCTING TRANSITION OF A ROTATING SUPERCONDUCTOR—THE HOLLOW CYLINDER**
Hilderbrandt, A. F., Saffren, M. M.
Technical Report No. 32-710 (Unclassified)
(Reprinted from *Low Temperature Physics-LT9 (Part A)*, Plenum Press, 1965, pp. 459-465)

For abstract, see Entry H18.

San Miguel, A.

- S02 ON THE CHARACTERIZATION OF MULTIAXIAL DATA IN TERMS OF THE STRAIN ENERGY CONCEPT**
San Miguel, A.
Technical Report No. 32-675, October 15, 1965
(Unclassified)

An experimental-theoretical approach based on continuous media theory has been suggested as a means of characterizing the multiaxial mechanical behavior of solid propellants. The applicability of this approach to solid propellants has been the subject of one research program at the Jet Propulsion Laboratory. Two multiaxial experiments that have been developed in this program are the inflated cylinder test and the biaxial sheet test. This Report deals with characterizing the multiaxial data from these tests in terms of strain energy; only the elastic portion of the viscoelastic response is considered. The ultimate aims of the study are to characterize materials with memory.

Schaeffle, W. E.

- S03 EVALUATION OF THE SIMULATED SOLAR SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR**
Drummond, A. J., Hickey, J. R., Schaeffle, W. E.
Technical Report No. 32-749, August 31, 1965
(Unclassified)

For abstract, see Entry D07.

Schlue, J. W.

- S04 THE DYNAMIC ENVIRONMENT OF SPACECRAFT SURFACE TRANSPORTATION**
Schlue, J. W.
Technical Report No. 32-876, March 15, 1966
(Unclassified)

The data in this Report result from a study of the shock and vibration environment imposed on a spacecraft during surface transportation. Acceleration amplitude statistics and predominant frequencies of different locations within a typical air-ride suspension van are presented.

The Appendix discusses instrumentation requirements associated with the acquisition of transportation data.

Schmitz, B. W.

- S05 DEVELOPMENT OF THE POST-INJECTION PROPULSION SYSTEM FOR THE MARINER-C SPACECRAFT**
Schmitz, B. W., Groudle, T. A., Kelly, J. H.
Technical Report No. 32-830, April 1, 1966
(Unclassified)

This Report describes the design, development, and operation of the post-injection propulsion system utilized in the *Mariner C* spacecraft. The propulsion unit consists of a small monopropellant, hydrazine-fueled rocket of 50-lbf vacuum thrust, capable of delivering a variable total impulse in conjunction with a timer-shutoff system. Functionally, the rocket is of the pressure-fed constant-thrust type. Injection pressure is obtained from a compressed gas—nitrogen—that passes through a pressure regulator and forces the propellant from a bladder-tank to the rocket engine. The rocket engine contains a quantity of catalyst to accelerate the decomposition of anhydrous hydrazine. Engine ignition is accomplished through the injection of a small quantity of a hypergolic oxidizer, nitrogen tetroxide. All valving functions for the propulsion unit are accomplished with explosively actuated valves. The propulsion system is capable of two ignitions and thrust terminations. Inflight performance of the propulsion system as a portion of the *Mariner III* and *Mariner IV* missions is described.

Schnopper, H. W.

- S06 A RUGGEDIZED THIN-WINDOW PROPORTIONAL-COUNTER TUBE**
Shields, R. A., Schnopper, H. W.
Technical Memorandum 33-221, September 15, 1965
(Unclassified)

For abstract, see Entry S11.

Schultz, C. W.

- S07 THERMOELECTRIC POWER IN NIOBIUM-ZIRCONIUM ALLOYS**
Weinberg, I., Schultz, C. W.
Technical Report No. 32-872 (Unclassified)
(Reprinted from *The Journal of Physics and Chemistry of Solids*, Vol. 27, 1965, pp. 474-476)

For abstract, see Entry W08.

Selvidge, J. E.

S08 RELATIVE INTENSITY CALCULATIONS FOR CARBON DIOXIDE

Gray, L. D., Selvidge, J. E.

Technical Report No. 32-817 (Unclassified)

(Reprinted from the *Journal of Quantitative Spectroscopy and Radiative Transfer*, Vol. 5, No. 2, March-April 1965, pp. 291-301)

For abstract, see Entry G15.

Shapiro, J. L.

S09 DESIGN STUDY OF A FISSION-ELECTRIC CELL REACTOR

Shapiro, J. L.

Technical Report No. 32-741, August 1, 1965

(Unclassified)

A design approach is developed for the application of a fission-electric cell reactor to the generation of power in space. For a graphite-moderated reactor, the total size, temperature, and total power are fixed. The remaining parameters, including cell dimensions and voltage, are then selected to optimize the overall efficiency.

From the standpoint of overall efficiency, it is shown that the two-region core is advantageous only for low-efficiency systems and hence offers little promise. Another important result of these calculations is that the optimum operating voltage is shifted downward from the optimum as calculated without considering criticality limitations. This means that the maximum efficiency achievable is reduced considerably and indicates that the criticality requirement may be a more severe limitation on efficiency than the effect of voltage breakdown within the cell.

Sherman, F. S.

S10 EXPERIMENTAL METHODS IN RAREFIED GAS DYNAMICS: THE STRUCTURE AND UTILIZATION OF SUPERSONIC FREE JETS IN LOW DENSITY WIND TUNNELS

Ashkenas, H., Sherman, F. S.

Technical Report No. 32-869 (Unclassified)

(Reprinted from *Rarefied Gas Dynamics*, Vol. 2, 1966, pp. 84-105)

For abstract, see Entry A10.

Shields, R. A.

S11 A RUGGEDIZED THIN-WINDOW PROPORTIONAL-COUNTER TUBE

Shields, R. A., Schnopper, H. W.

Technical Memorandum No. 33-221, September 15, 1965

(Unclassified)

The design and testing of a thin-window proportional-counter tube are described. The objective of this investigation was the development of a component suitable for use in

space experiments involving the detection of X-rays from light elements. The stability, efficiency, and resolution of the tube described here are consistent with space-application requirements. In a series of tests, it was determined that 0.25-mil aluminum-coated Mylar, supported by a nickel screen, provided maximum strength with minimum absorption. Two methods of sealing the window are described: (1) an O-ring and (2) a potting compound. Sodium K α pulse-height distributions from the thin-window tubes are compared with those from a standard commercial tube having a mica window.

Shlichta, P. J.

S12 EFFECT OF PREDEFORMATION ON THE MECHANICAL PROPERTIES OF SODIUM CHLORIDE CRYSTALS

Shlichta, P. J.

Technical Report No. 32-923, April 1, 1966

(Unclassified)

Sodium chloride crystals were grown from melt as uniform $\langle 100 \rangle$ rods, 3 to 5 mm in diam with flat $\{100\}$ faces. The mechanical properties of these as-grown crystals were compared with those of predeformed crystals and with annealed, water-polished cleavages of comparable size, purity, and dislocation density. Bend tests were performed using four-point loading at strain rates of 1.5 to 3×10^{-5} /sec. The load and deflection data were reduced, under the assumption of quasi-elastic behavior, to obtain T , the outer-fiber $\{110\} \langle 110 \rangle$ shear stress and E , the outer-fiber tensile strain.

The stress-strain curves of the as-grown crystals were similar to those of face-centered cubic metals; they showed a sharp yield point, a region of easy glide of slope $G_I = dT/dE$, and a second stage of increased work-hardening rate beginning at 5.5 to 8% strain. A linear relation existed between G_I , the yield stress (T_y), and the calcium concentration (C):

$$G_I \simeq 33.5 (T_y - 18) \simeq 184C$$

This suggests that a pure, as-grown crystal would have a yield stress of 18 g/mm² and virtually no work hardening during the first stage of deformation.

In contrast, the stress-strain curves of the predeformed crystals and cleavages showed numerous idiosyncrasies, such as anelastic feet and soft vs stiff behavior. Moreover, the G_I of these specimens was invariably higher than that predicted for as-grown crystals of comparable yield stress. These idiosyncrasies are, therefore, attributed to artifacts (e.g., slip bands) introduced during cleavage or predeformation. The soft vs stiff effect is attributed to the orientation of the predeformation slip systems with respect to those activated during the test; the effect is, therefore, related to the phenomenon of latent hardening, which apparently persists through annealing.

Although the as-grown crystals were exposed to diverse atmospheric environments prior to testing, there was no indi-

cation of embrittlement. This suggests that the embrittlement of cleavages is due to the interaction of emerging slip bands with the atmosphere. The only effect of water polishing was to increase the rate of stage II work hardening. When bent under water, however, the as-grown crystals showed a dramatic increase in ductility and could be tied in knots. This increase in ductility cannot be accounted for by most of the current explanations of the Joffe effect; therefore, it is proposed that this dynamic Joffe effect is a consequence of the enhanced solubility of stressed crystal surfaces.

It is concluded that most of the inconsistencies in the existing literature on the mechanical properties of sodium chloride crystals are the result of artifacts introduced during cleavage or polishing. Therefore, only as-grown crystals, of the highest possible purity and perfection, should be used in future research on the subject.

- S13 GROWTH DEFORMATION, AND DEFECT STRUCTURE OF SALT CRYSTALS**
Shlichta, P. J.
Technical Memorandum No. 33-274, February 15, 1966
(Unclassified)

The growth and deformation of salt crystals are governed by, and in turn cause, defects in the crystal structure. A detailed study of these defects might therefore yield considerable information in which it occurs. This paper presents some examples of the study of these lattice defects and their application to geological problems.

Shoemaker, E. M.

- S14 RANGER VIII AND IX. PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS**
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

Shumate, M. S.

- S15 INTERFEROMETRIC MEASUREMENT OF LARGE INDICES OF REFRACTION**
Shumate, M. S.
Technical Report No. 32-894 (Unclassified)
(Reprinted from *Applied Optics*, Vol. 5, No. 2, February 1966, pp. 327-328)

A method for determination of refractive indices which may be applied to thin flat plates of optical materials is considered. It is particularly suited for use with materials whose refractive indices are large (> 1.8), but is not limited in the range of refractive index it can determine. The method uses an interferometer to measure the optical pathlength through a sample, and is shown to have moderate accuracy: $\pm 2 \times 10^{-4}$ in refrac-

tive index for a sample 0.5 mm thick. The effect of a nonideal sample is considered, and is shown to have only a small effect on the accuracy. The method has been applied to single-crystal barium titanate in the visible spectrum, and tabulated results are given.

Sjogren, W. L.

- S16 THE RANGER III FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA**
Sjogren, W. L.
Technical Report No. 32-563, September 15, 1965
(Unclassified)

This Report describes the *Ranger III* tracking data obtained from the Deep Space Instrumentation Facility (DSIF) and the way in which these data were used to determine the spacecraft's orbit. The data are presented in the form of residual plots (i.e., the difference between the actual observed data and theoretical calculated data), and the resulting spacecraft orbit parameters are displayed in summary tables and the Orbit Determination Program (ODP) computer printout.

- S17 CHARACTERISTICS AND FORMAT OF THE TRACKING DATA TO BE OBTAINED BY THE NASA DEEP SPACE INSTRUMENTATION FACILITY FOR LUNAR ORBITER**
Lorell, J., Anderson, J. D., Sjogren, W. L.
Technical Memorandum No. 33-230, June 15, 1965
(Unclassified)

For abstract, see Entry L19.

Smith, G. E.

- S18 CONSTRAINTS-RESTRAINTS ANALOG PLOTTER PROGRAM**
Smith, G. E.
Technical Memorandum No. 33-222, July 15, 1965
(Unclassified)

The Constraints-Restraints Analog Plotter Program (CRAPP) is a digital computer program for mapping or plotting the various constraints, restraints, statistics and correction capabilities associated with the missions of certain spacecraft. This program, created at JPL, is written in Fortran II language for the IBM 7094 computer, and the primary output is plotting instruction for the SC-4020 Computer Recorder. A discussion of the theoretical basis of the program and flow diagrams of the computing procedures are presented. In addition, a complete discussion of input-output and samples with comments are included.

Smith, G. M.

- S19 RANGER PHOTOMETRIC CALIBRATION**
Smith, G. M., Willingham, D. E.
Technical Report No. 32-665, August 15, 1965
(Unclassified)

An equation is derived which relates collimator luminance values as read with a Pritchard photometer to actual lunar scene luminance values, so that identical *Ranger* camera responses occur. The solution of this equation requires detailed knowledge of emission spectra of the Moon, the collimator, a calibration standard, the spectral response characteristics of the "standard eye," the photometer, and each specific vidicon camera. Calculations are made for six typical *Ranger* cameras, and variations in the results from camera to camera are noted.

S20 EYES ON THE MOON

Smith, G. M., Vrebalovich, T., Willingham, D. E.
Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics*, Vol. 4,
No. 3, March 1966, pp. 74-82)

The *Ranger* program stocked a storehouse with more than 17,000 lunar photographs which supplied valuable aid to the scientific community in expanding its knowledge of the Moon. This Report gives a review of the *Ranger* photographic mission and presents a discussion of the results of the mission and its possible effect upon the future lunar missions.

Socha, A. J.

S21 MASS SPECTROGRAPHIC ANALYSES OF NONCONDUCTING CERAMICS

Socha, A. J., Leipold, M. H.
Technical Report No. 32-815 (Unclassified)
(Reprinted from the *Journal of the American Ceramic Society*, Vol. 48, No. 9, September 1965, pp. 463-466)

A technique for analysis of powdered or densified nonconductive materials by spark source mass spectrography is based on the use of a conducting probe against the compacted sample to initiate sparking.

Results on MgO show significant quantities of anion impurities which are not generally reported. Analysis of CdS powder indicate low contamination from sample preparation.

Space Simulator Staff

S22 SPACE SIMULATOR FACILITIES AT THE JET PROPULSION LABORATORY

Space Simulator Staff
Technical Memorandum No. 33-197, March 1, 1965
(Unclassified)

This Memorandum describes the space simulator facilities currently available at the Jet Propulsion Laboratory. The description includes temperature, pressure, and irradiation capabilities, test instrumentation available, and data handling.

Speed, R. C.

S23 A LUNAR X-RAY DIFFRACTION EXPERIMENT

Speed, R. C., Nash, D. B., Nickle, N. L.
Technical Report No. 32-756 (Unclassified)
(Reprinted from *Advances in X-Ray Analysis*, Vol. 8,
Plenum Press, 1965, pp. 400-419)

An X-ray diffraction system is under development for remote analysis of lunar rocks from an unmanned, soft-landed spacecraft. The objective of this experiment is the identification of rock-forming phases and estimation of their abundances, compositions, and other data which are indicative of the nature of genetic processes on the Moon. A 2:1 scanning parafofocusing geometry was successfully miniaturized for this purpose, and a complete diffraction system based on the design is in preparation. The diffractometer including high-voltage power supply weighs 18 lb, occupies 0.9 ft³, and requires 56 w of continuous power. A sample acquisition and preparation system will be an integral part of the diffractometer. Diffraction analysis of a rhyolite, basalt, and chondritic meteorite are given as examples of the capabilities and limitations of rock analysis by this method.

S24 LUNAR AND PLANETARY X-RAY DIFFRACTION PROGRAM

Hess, H. H., Speed, R. C.
Technical Memorandum No. 33-218 (Progress Report of
Research and Instrument Development July 1964 to
March 1965), June 1, 1965 (Unclassified)

For abstract, see Entry H14.

S25 THE UTILITY OF UNMANNED PROBES IN LUNAR SCIENTIFIC EXPLORATION

Speed, R. C., Nash, D. B., Adams, J. B.
Technical Memorandum No. 33-241, July 15, 1965
(Unclassified)

The utility of unmanned lunar survey probes of the *Ranger* and *Surveyor* class in the post-Apollo scientific exploration program, *Apollo Extension Systems* (AES), is defined. Missions, measurements, instruments, probe types, and probe requirements are evaluated, and priorities are established. It is shown that the most important role for unmanned probes is one of widespread reconnaissance which attempts to define and amplify broad lunar problems; and to delineate the most significant areas on the Moon for subsequent, detailed investigations by manned vehicles.

Spencer, D. F.

S26 ENGINEERING MODELS OF THE MARTIAN ATMOSPHERE AND SURFACE

Spencer, D. F.
Technical Memorandum No. 33-234, July 1, 1965
(Unclassified)

Engineering models of the Martian atmosphere and surface are developed for application in designing a Mars capsule-lander. Models are presented for various surface pressures and a number of low-altitude and stratospheric temperature profiles. An atmospheric surface pressure of 14 mb is suggested for design use. Mean continuous wind velocities of approximately 100 ft/sec at the surface are recommended with a mean vertical gradient of plus 2 ft/sec/1000 ft. A peak design wind

velocity of 330 ft/sec is recommended consistent with a 14-mb surface pressure. Models of Mars' surface are developed for the bright areas and the dark areas. The significant differences in design requirements for these areas result from: (1) the convex and concave low-scale surface contours in the dark areas; (2) design requirement to accommodate 10-cm rocks in the dark areas.

Stacey, J.

S27 RADIOMETRIC MAPPING OF THE MOON AT 3 MILLIMETERS WAVELENGTH

Gary, B., Stacey, J., Drake, F. D.

Technical Report No. 32-838 (Unclassified)

(Reprinted from *The Astrophysical Journal, Supplement Series*, Vol. 12, No. 108, November 1965, pp. 239-262)

For abstract, see Entry G02.

Stelzried, C. T.

S28 A PRECISION DC-POTENTIOMETER MICROWAVE INSERTION-LOSS TEST SET

Stelzried, C. T., Reid, M. S., Petty, S. M.

Technical Report No. 32-887, March 15, 1966

(Unclassified)

A requirement has existed at the Jet Propulsion Laboratory for an instrument capable of measuring the insertion loss of transmission-line components beyond the normal precision capability of commercially available equipment. These measurements are necessary for the calibration of low-noise microwave receiving systems used in planetary and lunar astronomy and space communications programs. The instrumentation which was developed has a short-term jitter of 0.0004 db peak-to-peak and long-term drift of typically 0.0015 db/hr. Accuracy of the measurements is limited at the higher insertion-loss values by a 0.1% instrumentation nonlinearity. The precision at very low insertion-loss levels is shown to be better than 10^{-4} db.

Stephens, J. B.

S29 SPACE MOLECULAR SINK SIMULATOR FACILITY DESIGN

Stephens, J. B.

Technical Report No. 32-901, March 15, 1966

(Unclassified)

This Report summarizes the results of research, design, and development efforts for a space molecular sink simulation facility now under construction. The longitudinal-wedge-fin, 21°K hydrogen-refrigerated, molecular-trap array has been shown to provide a capture improvement of an order of magnitude over that of smooth-walls, capturing 99.97% of the condensable molecules of O₂, N₂, CO, and CO₂ that emanate from the test item before they can return. An electron-beam titanium sublimator will be used to pump hydrogen and, also, chemically permanently fix the cryo deposits. A 1300-ft³/min

mechanical pump (operated in the viscous-flow regime to eliminate backstreaming) and a 140-l/sec turbo-molecular impact pump will be used to rough pump the double-walled, double-doored 10-ft-diam vacuum chamber and to sustain the guard vacuum. The chamber is decontaminated by glass-bead blasting in conjunction with a 250°C vacuum bake-out. Conventional extreme-high-vacuum and cryogenic instrumentation and controls will be used; cryogenic quartz-crystal microbalances with a sensitivity of 1×10^{-10} g/cm² will be used to measure condensable molecular fluxes; and a cryogenic quadrupole mass spectrometer will be used to monitor the molecular specie emanating from the test item.

Surveyor Project Office

S30 SURVEYOR MISSION OPERATIONS SYSTEM

Surveyor Project Office

Technical Memorandum No. 33-264, April 4, 1966

(Unclassified)

The purpose of this Technical Memorandum is to provide a basic understanding of the mission operation system (MOS). Treatment of the subject contains sufficient detail to convey an accurate knowledge of the workings of the entire system. Technical data and information about all elements of the MOS are found in the official MOS planning, design and operational documents which this Memorandum summarizes. This publication is made up of five sections. The description of the MOS is developed in the first four. The fifth is a presentation of an over-all view of the communications that take place during the mission and the spaceflight activities controlled by these communications.

Tausworthe, R. C.

T01 A PRECISION PLANETARY RANGE-TRACKING RADAR

Tausworthe, R. C.

Technical Report No. 32-779 (Unclassified)

(Reprinted from *IEEE Transactions on Space Electronics and Telemetry*, Vol. SET-11, No. 2, June 1965, pp. 78-85)

A closed-loop range-locked radar system developed by the Jet Propulsion Laboratory has recently had great success range tracking the planet Venus. It has provided measurements to the planetary mean-tracking point with peak minute-to-minute variations less than 2.25 to 3 km in range. Over a one-hour tracking period, a mean tracking point can be determined to 0.5 km.

A scattering-law calibration of the planet is made each day, measuring the mean-tracking-point-to-planetary-surface distance to within 3 km (nominal). The subearth point-to-radar distance is thus measured to a nominal accuracy of 3.5 km. Tracking behaves as a first-order linear "range-locked" loop with ephemeris aid, and is practically calibration free.

Data obtained during the 1964 conjunction showed that the ephemeris not only contained a range error, but also a range-

rate error of 18 km per day. Deviations from this rate correspond to surface features whose height can be estimated. Such data will be invaluable in determining, to a greater degree of accuracy than ever before attainable, the orbital constants of the Earth and Venus.

T02 THEORY AND PRACTICAL DESIGN OF PHASE-LOCKED RECEIVERS—VOLUME I

Tausworthe, R. C.

Technical Report No. 32-819, February 15, 1966

(Unclassified)

This is Volume I of a two-volume work on the theory of phase-locked receivers with pertinent reference material on practical receiver design. Volume I is primarily devoted to the performance of carrier-tracking loops including treatment of narrow-band systems having IF limiters. The bulk of the work is based on a theoretical linear model.

Part 1 is an exposition of the theory, the resulting equations and design philosophy that have enabled the phase-lock concept to evolve into the basic principle underlying the most sensitive receivers. Part 2 is a condensed version of Part 1, for quick reference to formulas, definitions and salient design considerations.

Taylor, H. S.

T03 MANY-ELECTRON-THEORY AB INITIO CALCULATION FOR THE Be ATOM

Geller, M., Taylor, H. S., Levine, H. B.

Technical Report No. 32-799 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 5, September 1965, pp. 1727-1736)

For abstract, see Entry G06.

Taylor, J. L.

T04 SLIP IN TUNGSTEN AT HIGH TEMPERATURES

Taylor, J. L.

Technical Report No. 32-818, October 15, 1965

(Unclassified)

Single crystals of tungsten grown from powder-metallurgy swaged rod by high temperature annealing were deformed in tension at temperatures from 2500 to 5000°F. Orientation of specimen tensile axis, strained matrix, and deformation bands was determined optically by reflections from {110} etch pits. Slip traces were analyzed and slip direction determined. Results indicate that {110} <111>, {112} <111>, and {123} <111> type slip occur in tungsten over the temperature range investigated. Slip is orientation dependent occurring on that combination of slip plane and direction which has the highest critical resolved shear stress. "Overshooting" appears to be a general occurrence between 2500 and 5000°F. Deformation bands show rotation in a direction opposite to the rotation of the tensile axis.

T05 TENSILE BEHAVIOR OF SAME-LOT SINGLE-CRYSTAL AND POLYCRYSTALLINE TUNGSTEN FROM 2500 TO 5000°F

Taylor, J. L.

Technical Report No. 32-827, November 15, 1965

(Unclassified)

Polycrystalline tungsten of the same lot and chemical composition as the single-crystal material also was tested under the same conditions of strain rate and temperature. The tensile results were consistent with results previously reported by the author for other lots of polycrystalline powder-metallurgy tungsten, including a ductility minimum at $\approx 3500^\circ\text{F}$ and a maximum at $\approx 4500^\circ\text{F}$. It appears that orientation may be a factor in the ductility minimum in polycrystalline tungsten, presuming that the many small crystals making up the core of the polycrystalline specimens exhibit the same preferred orientation as the single-crystal material. The maximum in elongation which also occurs in both polycrystalline and single-crystal tungsten may be similarly related through preferred orientation. Comparison of polycrystalline and single-crystal tungsten indicated an upper limit of ≈ 2 -1 to the strengthening effect due to grain size at 2500°F and above.

Thomas, G. M.

T06 EXPERIMENTAL MEASUREMENTS OF NON-EQUILIBRIUM AND EQUILIBRIUM RADIATION FROM PLANETARY ATMOSPHERES

Thomas, G. M., Menard, W. A.

Technical Report No. 32-902 (Unclassified)

(Reprinted from *AIAA Journal*, Vol. 4, No. 2, February 1966, pp. 227-237)

An electric arc-driven shock tube was used to study the effect of composition on the radiation from shock-heated mixtures of 9% CO_2 -90% N_2 -1% A, 30% CO_2 -70% N_2 , and 100% CO_2 . Measurements were made of the shock-layer radiance at the stagnation point of a flat-faced cylinder in the 0.3- to 2.7- μ region, using a carbon-coated thin film gage for flight velocities from 20,000 to 46,000 fps and initial pressures varying from 0.25 to 2.00 mm Hg. Shock standoff distances were measured by photographic techniques. Photometric measurements were made of the intensity behind the incident shock in the 0.3- to 1.0- μ region, and a tungsten photoelectric gage measured the nonequilibrium intensity in the far ultraviolet region. Shock front integrated nonequilibrium and equilibrium intensities, nonequilibrium relaxation distances, and time to peak intensity were obtained. Stagnation-point radiance results are higher than one current estimate at high temperatures and low densities. Integrated nonequilibrium intensity for 9% CO_2 -90% N_2 -1% A mixtures was $32\text{w/cm}^2\cdot 2\pi\text{ sr}$ at 25,000 fps. Major radiating species are identified as the CN radical for CO_2 - N_2 mixtures and the CO^+ ion for 100% CO_2 . Oscillator strengths for the CN red and violet systems are deduced from the measurements. The f value results indirectly give support to a dissociation energy of $7.7 \pm 0.1\text{ eV}$ for the CN radical.

Thornton, T. H., Jr.

T07 INJECTION ACCURACY CHARACTERISTICS FOR LUNAR MISSIONS

Thornton, T. H., Jr.

Technical Report No. 32-839, October 15, 1965

(Unclassified)

Report investigates a technique for expressing launch vehicle injection accuracy in terms of spacecraft midcourse correction requirements for Earth-Moon missions. A figure-of-merit is defined which can be used as a measure of injection accuracy. The variables important to guidance accuracy such as injection energy, launch azimuth, lunar declination and Earth-Moon distance are discussed. A "best" target coordinate system is developed and numerical results which enable the engineer to relate launch vehicle injection accuracy to spacecraft midcourse correction requirements are presented. Both "miss-only" type midcourse corrections and "miss-plus-time" corrections are considered.

Toth, L. R.

T08 ALPS GENERANT TANK AND CELL ASSEMBLY

Keller, O. F., Toth, L. R.

Technical Report No. 32-865, February 28, 1966

(Unclassified)

For abstract, see Entry K05.

Trajmar, S.

T09 INDUCED INFRARED ABSORPTION OF SOLUTIONS OF H_2 AND D_2 IN LIQUID NEON

Ewing, G. E., Trajmar, S.

Technical Report No. 32-764 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 11, June 1, 1965, pp. 4038-4046)

For abstract, see Entry E12.

T10 THE NEAR-ULTRAVIOLET BANDS OF MgO : ANALYSIS OF THE $D^1\Delta - A^1\Pi$ AND $C^1\Sigma^- - A^1\Pi$ SYSTEMS

Trajmar, S., Ewing, G. E.

Technical Report No. 32-770 (Unclassified)

(Reprinted from *The Astrophysical Journal*, Vol. 142, No. 1, July 1, 1965, pp. 77-83)

The near-ultraviolet bands of $Mg^{16}O$ and $Mg^{18}O$ have been photographed in the second order with a 21-foot concave grating spectrograph using a controlled-atmosphere arc source. It has been found that the $C^1\Delta - A^1\Pi$ system extends from 3766 Å to about 3800 Å, and the bands from 3798 Å to the longer wavelengths belong to the $D^1\Delta - A^1\Pi$ system forming a zero sequence ($\Delta v = 0$). Vibrational and rotational analysis of this latter system yields the following constants for the new $D^1\Delta$ state of $Mg^{16}O$: $\omega_e = 632.5$, $\omega_e x_e = 5.3$, $B_0 = 0.4990$, $D_0 = 1.26 \times 10^{-6}$, $B_1 = 0.4942$, and $D_1 = 1.29 \times 10^{-6} \text{ cm}^{-1}$. The Δ -doubling is resolved in the (0-0) band and causes double head formation in the R branches.

The assignment of the $C^1\Sigma - A^1\Pi$ system reported earlier has been somewhat modified and extended. The symmetry of the upper state has been changed from $C^1\Sigma^+$ to $C^1\Sigma^-$, the J -numbering in the Q branch of the (0-0) band has been shifted by one, and the assignment of the (1-1) band has been achieved. The constants of the $C^1\Sigma^-$ state of $Mg^{16}O$ are: $\omega_e = 632.4$, $\omega_e x_e = 5.2$, $B_0 = 0.4984$, $D_0 = 1.27 \times 10^{-6}$, $B_1 = 0.4936$, and $D_1 = 1.30 \times 10^{-6} \text{ cm}^{-1}$.

Trubert, M. R.

T11 USE OF RANGER FLIGHT DATA IN THE SYNTHESIS OF A TORSIONAL ACCELERATION TRANSIENT FOR SURVEYOR VIBRATION QUALIFICATION TESTING

Trubert, M. R.

Technical Memorandum No. 33-237, April 19, 1966

(Unclassified)

This Technical Memorandum presents a method for the prediction of the flight acceleration at the base of a spacecraft in boost configuration from the flight data of another spacecraft using the same first-stage booster. The predicted acceleration furnishes a rational basis for the vibration specifications of the spacecraft. The method is illustrated with the torsional acceleration of the *Ranger* and *Surveyor* spacecraft. The study was made in three steps: In Step I, the pulsating transient acceleration, recorded at the base of *Ranger* during Flights VI through IX (booster engine cutoff event), was analyzed. A pulse-type torque at the gimbal blocks of the *Atlas* engine was assumed to be cause of the transient acceleration and was determined on an analog computer. In Step II, this torque was applied on an analog model of the *Atlas/Centaur/Surveyor* vehicle; the corresponding acceleration at the base of *Surveyor* was deduced. In Step III, the attention was focused on the implementation of the pulse test program. In addition, recommendation for a sine sweep test was made by deriving a sine level that is equivalent to the pulses.

Trummel, M. C.

T12 APPLICATION OF GROUND-TEST ACOUSTIC SIMULATIONS OF LIFTOFF AND TRANSONIC VIBRATION TO ACTUAL RANGER FLIGHT VIBRATION DATA

Trummel, M. C.

Technical Report No. 32-910, May 1, 1966

(Unclassified)

During the *Ranger* flight program, only a limited amount of in-flight vibration data was obtained. In order to expand the usefulness of this data, a ground test was conducted in which a large number of vibration and acoustic measurements were made. The test approximated, by the use of acoustic fields, the vibration excitation mechanisms existing at the flight periods of maximum vibration: liftoff and transonic. By using the ground test data in conjunction with the flight data, the following results were achieved: (1) The nature of the vibration caused by the two excitation modes was determined, and the

effect of flight accelerometer characteristics on measured vibration was analyzed. (2) A method of predicting vibration levels was developed and, by comparison with the actual flight data, was shown to be adequate at higher frequencies, but overly conservative at lower frequencies. (3) The flight vibration environment at the *Ranger* spacecraft feet and at two general classes of equipment locations on the spacecraft was estimated and shown to be adequately covered by vibration test specifications.

T13 GROUND TEST SIMULATION OF LIFT-OFF AND TRANSONIC VIBRATION EXCITATION MECHANISMS ON THE RANGER SPACECRAFT

Trummel, M. C.

Technical Memorandum No. 33-256, November 1, 1965
(Unclassified)

The results of extensive vibration measurements from ground test acoustic simulations of *Ranger* spacecraft launch and transonic vibration excitation modes are presented. For analysis the measurements are grouped into three structurally similar regions. The data from a typical region are statistically analyzed in narrow frequency bands and the 95-percentile value is compared to the 50-percentile value. A method of using acoustic acceptance measurements to predict launch vibration levels is developed and compared with actual *Ranger* flight data. The distribution of vibration over the spacecraft and the directionality of excited vibration are compared under both modes of vibration excitation.

Tschuikow-Roux, E.

T14 REACTION DWELL TIME AND COOLING RATE IN A SINGLE-PULSE SHOCK TUBE

Tschuikow-Roux, E.

Technical Report No. 32-752 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 5, May 1965, pp. 821-825)

A method for the production of a constant, well-defined reaction dwell time in a single-pulse shock tube is discussed and an expression is derived giving the dwell time in terms of geometric and flow parameters. The effect of finite cooling rate on the reaction rate is considered and a correction factor to the observed rate constant is given. This cooling correction is shown to be directly proportional to T^2 , inversely proportional to the cooling rate dT/dt , and the reaction dwell time t_1 , and, to a first approximation, independent of the heat-capacity ratio, $\gamma = C_p/C_v$.

T15 THERMAL DECOMPOSITION OF FLUOROFORM IN A SINGLE-PULSE SHOCK TUBE.

II. PRESSURE DEPENDENCE OF THE RATE

Tschuikow-Roux, E.

Technical Report No. 32-753 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 10, May 15, 1965, pp. 3639-3642)

The thermal decomposition of CF_3H has been studied in a single-pulse shock tube between 1200 and 1600°K using dilute $\text{CF}_3\text{H-Ar}$ mixtures at total pressures of about 18.7 and 0.90 atm. The results, together with earlier work at about 4 atm, indicate that the observed rate constants for the rate of disappearance of CF_3H are those of a second-order energy-transfer process, where collisional activation is rate determining. Kassel's model of unimolecular reaction-rate theory is used to show that the observed pressure dependence of the rate constants is not unreasonable. From the classical Kassel theory for such processes, it is calculated that the mean lifetime of a critically energized CF_3H at 1400°K is 1.2×10^{-11} sec with five effective oscillators.

T16 KINETICS OF THE THERMAL DECOMPOSITION OF C_2F_6 IN THE PRESENCE OF H_2 AT 1300-1600°K

Tschuikow-Roux, E.

Technical Report No. 32-826 (Unclassified)

(Reprinted from *The Journal of Chemical Physics*, Vol. 43, No. 7, October 1965, pp. 2251-2256)

The thermal decomposition of hexafluoroethane in the presence of hydrogen has been studied in a single-pulse shock tube in the temperature range 1300 to 1600°K. The reactants were highly diluted with argon, the composition ratios being $\text{Ar:H}_2:\text{C}_2\text{F}_6 \approx 7500:17.4:1$. The principal reaction products containing carbon were fluoroform and tetrafluoroethylene. A reaction scheme which accounts for these products is proposed and the first-order rate constant for the primary step $\text{C}_2\text{F}_6 \rightarrow 2\text{CF}_3$ is deduced: $k_1 = 4.3 \times 10^{17} \exp(-94400 \pm 4000)/RT \text{ sec}^{-1}$.

Accepting an activation energy of about 1 kcal/mole for the recombination of CF_3 radicals leads to $D(\text{CF}_3 - \text{CF}_3) \approx 93 \pm 4$ kcal/mole.

Tyler, W. H.

T17 THE EFFECT OF INJECTOR DESIGN ON THRUST-CHAMBER EROSION

Rowley, R. W., Tyler, W. H.

Technical Report No. 32-750, March 1, 1966
(Unclassified)

For abstract, see Entry R34.

Urey, H. C.

U01 RANGER VIII AND IX.

PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS

Heacock, R. L., Kuiper, G. P., Shoemaker, E. M.,

Urey, H. C., Whitaker, E. A.

Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

Vango, S. P.

- V01 DETECTION OF MICRO-ORGANISMS IN SOIL BY THEIR CATALATIC ACTIVITY**
Weetall, H. H., Weliky, N., Vango, S. P.
Technical Report No. 32-777 (Unclassified)
(Reprinted from *Nature*, Vol. 208, No. 4988, June 5, 1965 pp. 1019-1021)

For abstract, see Entry W04.

Vrebalovich, T.

- V02 EYES ON THE MOON**
Smith, G. M., Vrebalovich, T., Willingham, D. E.
Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics*, Vol. 4, No. 3, March 1966, pp. 74-82)

For abstract, see Entry S20.

Wada, B.

- W01 STIFFNESS MATRIX STRUCTURAL ANALYSIS**
Wada, B.
Technical Report No. 32-774, October 31, 1965
(Unclassified)

A computer program is described that solves structural problems having lumped masses connected by weightless members. The program is capable of handling 130 degrees of freedom with the option of using any one of five different member types.

Using the stiffness formulation, static deflections and loads, thermal deflections and loads, eigenvalues and eigenvectors can be evaluated.

Wahlquist, H. D.

- W02 RIGID MOTIONS IN EINSTEIN SPACES**
Wahlquist, H. D., Estabrook, F. B.
Technical Report No. 32-868, March 15, 1966
(Unclassified)

The dyadic formulation of general relativity is used systematically to discuss rigid congruences in Einstein space-time. For space-time of uniform curvature, the quotient space metrics of rotating and accelerating rigid bodies are obtained. For Einstein space-time of nonuniform curvature, all irrotational, nonisometric, rigid motions are explicitly displayed. They have one degree of freedom, and occur only in degenerate static metrics of Class B. Rotating rigid congruences in Einstein space-time of nonuniform curvature are shown to have no degrees of freedom. Their evolution is, in fact, found to be governed by a complete set of 14 first-order total differential equations, linear in the time derivatives of the dyadic variables. Such rotating motions are shown further to be constrained by a set of algebraic conditions; the implication of this for the validity of the Herglotz-Noether theorem in Einstein space-time is discussed.

Weetall, H. H.

- W03 IMMUNOADSORBENT FOR THE ISOLATION OF PURINE-SPECIFIC ANTIBODIES**
Weetall, H. H., Weliky, N.
Technical Report No. 32-758 (Unclassified)
(Reprinted from *Science*, Vol. 148, No. 3674, May 28, 1965, pp. 1235-1237)

An immunoadsorbent for the isolation of purine-specific antibody has been synthesized. The technique is applicable for isolating antibody to any purine or pyrimidine capable of being converted to a derivative which can be coupled to amine groups. The recovery of antibody from a serum sample is better than 82%, and the precipitability of the isolated antibody is as high as 89%.

- W04 DETECTION OF MICRO-ORGANISMS IN SOIL BY THEIR CATALATIC ACTIVITY**
Weetall, H. H., Weliky, N., Vango, S. P.
Technical Report No. 32-777 (Unclassified)
(Reprinted from *Nature*, Vol. 208, No. 4988, June 5, 1965, pp. 1019-1021)

Method of detecting and estimating intracellular catalase, an enzyme which catalyzes the decomposition of hydrogen peroxide to water and oxygen, is a simple and convenient indicator of the presence of micro-organisms in soils. Catalase is prevalent in microorganisms, and its activity is insensitive to reaction conditions. To determine the concentrations of intracellular catalase which might be found in various desert soils, the quantity of enzyme found in an "average bacterium" was estimated. The principle of the method was tested by placing equal weights of soil samples in the bottom of each of two test tubes. Buffer was added to the control side and muramidase in an equal volume of buffer to the other. After allowing 20 min for the muramidase to react, the upper reagent vessels were turned so that the hydrogen peroxide solution, previously measured into each, was poured into the test tubes. If the muramidase released catalase, the excess oxygen produced from the hydrogen peroxide increased the pressure on that side, causing the liquid in an interconnecting U-tube to move. This was found to be the case for a garden soil and several desert soils. It is considered that the technique, which has been refined in a manner described, should be applicable to the detection of an enzyme which produces a gas such as carbon dioxide or oxygen.

- W05 THE COUPLING OF BIOLOGICALLY ACTIVE MOLECULES TO INSOLUBLE POLYMERS: ANTIBODY ON CELLULOSE**
Weetall, H. H., Weliky, N.
Technical Report No. 32-802 (Unclassified)
(Reprinted from *Biochimica et Biophysica Acta*, 107, 1965, pp. 150-152)

Antibody globulin has been coupled to a diazotized aminoaryl derivative of carboxymethyl-cellulose to form an immunoadsorbent which specifically retains and releases specific antigen. Such substances may be useful for the isolation

of substances with antigenic properties which are difficult to handle by other methods, after optimum conditions for stability and yield have been determined. Insoluble antibody derivatives may be used for antigen-antibody dissociation studies or to investigate antibody denaturation mechanisms by agents which cause loss of activity.

W06 THE CHEMISTRY AND USE OF CELLULOSE DERIVATIVES FOR THE STUDY OF BIOLOGICAL SYSTEMS

Weelky, N., Weetall, H. H.

Technical Report No. 32-859 (Unclassified)

(Reprinted from *Immunochemistry*, Vol. 2, 1965, pp. 293-322)

For abstract, see Entry W14.

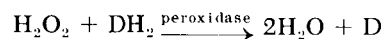
W07 A NEW TECHNIQUE FOR THE ENZYMIC DETECTION OF HYDROGEN PEROXIDE

Weetall, H. H., Weliky, N.

Technical Report No. 32-967 (Unclassified)

(Reprinted from *Analytical Biochemistry*, Vol. 14, No. 1, January 1966, pp. 160-162)

Enzymic methods for detecting the presence of small quantities of peroxides have been used since the first reported successful attempt in 1845 by Osann. With peroxidase as the enzyme, he was able to detect 6×10^{-5} M hydrogen peroxide. The method made use of peroxidase to catalyze the oxidation of a colorless hydrogen donor (DH_2) to a colored product (D) which could be determined colorimetrically. Schematically the reaction is as follows:



Weinberg, I.

W08 THERMOELECTRIC POWER IN NIOBIUM-ZIRCONIUM ALLOYS

Weinberg, I., Schultz, C. W.

Technical Report No. 32-872 (Unclassified)

(Reprinted from *The Journal of Physics and Chemistry of Solids*, Vol. 27, 1965, pp. 474-476)

The thermoelectric power of niobium exhibits a relatively positive peak at $T \approx 80^\circ\text{K}$. Assuming the presence of a phonon drag component, a change in the magnitude of this peak can be anticipated when sufficient amounts of zirconium are added to niobium. Information regarding the transport properties of simpler metals has been obtained by observing quenching of the phonon drag peak in copper-based alloys. A variation in diffusion thermopower with alloying is expected. To obtain information regarding the relatively unexplored transport properties of Nb-Zr alloys, the thermoelectric power of niobium and several Nb-Zr alloys from $T = 9 \cdot 2$ to 330°K must be determined. Since the original data extends to the low temperature limit of 14°K , the current results constitute an extension to lower temperatures of previously published results. Measurements were carried out on niobium and Nb-Zr alloys containing 1, 1.8 and 3.8 at. % zirconium as determined by spectrochemical analysis.

W09 PHONON-DRAG THERMOPOWER IN DILUTE COPPER ALLOYS

Weinberg, I.

Technical Report No. 32-879, April 1, 1966

(Unclassified)

The change in phonon-drag thermopower of copper that occurs with alloying is determined for several dilute copper alloys. These results are then used to determine numerical values for the scattering parameter a , assuming pure Rayleigh scattering of phonons by the solute atoms. The values of a obtained experimentally are compared to the scattering parameter calculated for elastic scattering of long-wavelength phonons by the mechanism of mass difference alone. Solute concentrations employed in this investigation are: 0.03 at. % Au, 0.09 and 0.2 at. % Ag, and 0.44 at. % Si. For Cu-Au, the results indicate that phonons are scattered predominantly through the mass-defect mechanism. The Cu-Si data yield a contribution from the mass-defect term that is of the same magnitude as the contribution from other phonon-scattering mechanisms. For Cu-Ag, the results indicate that phonons are scattered in this alloy predominantly by mechanisms other than mass difference. The relative magnitude of the lattice-distortion contribution is least in Cu-Au, and increases in Cu-Si and Cu-Ag in that order. The Cu-Si data are in agreement with the author's previous results, while for Cu-Ag and Cu-Au, the results are in agreement with qualitative considerations based on the range of solid solubilities in these alloys.

Weingart, J. M.

W10 DETERMINATION OF THE LOW-FREQUENCY LINEAR ELECTRO-OPTIC EFFECT IN TETRAGONAL, Ba TiO₃

Johnston, A. R., Weingart, J. M.

Technical Report No. 32-760 (Unclassified)

(Reprinted from *Journal of the Optical Society of America*, Vol. 55, No. 7, July 1965, pp. 828-834)

For abstract, see Entry J10.

Weliky, N.

W11 IMMUNOADSORBENT FOR THE ISOLATION OF PURINE-SPECIFIC ANTIBODIES

Weetall, H. H., Weliky, N.

Technical Report No. 32-758 (Unclassified)

(Reprinted from *Science*, Vol. 148, No. 3674, May 28, 1965, pp. 1235-1237)

For abstract, see Entry W03.

W12 DETECTION OF MICRO-ORGANISMS IN SOIL BY THEIR CATALATIC ACTIVITY

Weetall, H. H., Weliky, N., Vango, S. P.

Technical Report No. 32-777 (Unclassified)

(Reprinted from *Nature*, Vol. 208, No. 4988, June 5, 1965, pp. 1019-1021)

For abstract, see Entry W04.

W13 THE COUPLING OF BIOLOGICALLY ACTIVE MOLECULES TO INSOLUBLE POLYMERS: ANTIBODY ON CELLULOSE

Weetall, H. H., Weliky, N.

Technical Report No. 32-802 (Unclassified)

(Reported from *Biochimica et Biophysica Acta*, 107, 1965, pp. 150-152)

For abstract, see Entry W05.

W14 THE CHEMISTRY AND USE OF CELLULOSE DERIVATIVES FOR THE STUDY OF BIOLOGICAL SYSTEMS

Weliky, N., Weetall, H. H.

Technical Report No. 32-859 (Unclassified)

(Reprinted from *Immunochemistry*, Vol. 2, 1965, pp. 293-322)

The increasing number of publications dealing with the coupling of biologically important molecules or their substrates to soluble and particularly insoluble polymers reflects a growing acknowledgment of the usefulness of such systems for the isolation and synthesis of molecular species, the study of chemical and biological mechanisms, and the study of molecular interactions.

Examples of the uses to which such systems can be put include: (1) The coupling of antigens, antibodies, enzymes, enzyme inhibitors and nucleic acids (including fragments or monomers) in order to purify or isolate complementary substances with which they form specific or cross-reacting complexes. This includes the "sandwich technique" in which an antigen is coupled, antibody is complexed to the antigen, and advantage taken of the bivalence of antibody to detect or quantitate antigen by further exposure of the immunoadsorbent to solutions of that substance. Detection can be accomplished by radioactive labeling or by dissociation under appropriate conditions for the detection or recovery of the antigen.

(2) Study of the bound substance to observe the effect of coupling at different molecular sites on reactivity. For example it has been found that bovine serum albumin is as effective in removing antibody from immune serum, if coupled to cellulose through an azo link by reaction with a diazonium cellulose derivative, as by reaction with an acidic cellulose derivative to form an amide.

(3) Study of the bound substance to observe the effect of coupling on chemical properties such as reactivity of enzymes, or physical properties such as fluorescence.

(4) The study of the effects of reagents on the binding of complexed species with polymer bound molecules; e.g., acid dissociation.

(5) Bound substances may, in favorable cases, be localized in particular environments where their biological effects can be observed without the possibility of physical transfer and the introduction of ambiguities caused by possible interactions at other locations. This technique is applicable to enzyme, hormone and antibody systems. Potentially, the pos-

sibility exists that deficiencies in organisms may be supplemented by biologically active molecules bound to insoluble or soluble polymers.

(6) Model biological systems may be set up using bound enzymes, hormones and other biologically active molecules to study controlled sequential reactions.

(7) The step-wise synthesis of polymers in a controlled fashion may, in principle, be accomplished by binding a monomer and successively adding other components in high yield reactions. Some success has already been achieved in this area.

Reports of relatively high nonspecific adsorption of proteins by hydrocarbon polymers induced the re-examination of cellulose as a carrier for proteins, other polymers and simple organic molecules. The rest of this paper will be limited to a survey of the chemistry of cellulose and its derivatives as it applies to the preparation of systems useful for the study of biochemical substances and their properties.

W15 IMMUNOADSORBENT: PREPARATION AND USE OF CELLULOSE DERIVATIVES

Campbell, D. H., Weliky, N.

Technical Report No. 32-900, May 1, 1966

(Unclassified)

For abstract, see Entry C03.

W16 A NEW TECHNIQUE FOR THE ENZYMIC DETECTION OF HYDROGEN PEROXIDE

Weetall, H. H., Weliky, N.

Technical Report No. 32-967 (Unclassified)

(Reprinted from *Analytical Biochemistry*, Vol. 14, No. 1, January 1966, pp. 160-162)

For abstract, see Entry W07.

Wells, W. H.

W17 PROPOSED GAS MASER PUMPING SCHEME FOR THE FAR INFRARED

Wells, W. H.

Technical Report No. 32-616 (Unclassified)

(Reprinted from *Journal of Applied Physics*, Vol. 36, No. 9, September 1965, pp. 2838-2843)

A scheme that is analogous to the operation of a heat engine is proposed for exciting maser action in the infrared and submillimeter parts of the spectrum. A beam of hot molecules interacts through distant collision with a cold gas of another species at very low pressure. Certain energy levels in the hot gas are cooled faster than others owing to coincidental resonances in the spectra of the two gases. In the partially cooled nonequilibrium state, population inversions are possible in the hot species.

To demonstrate feasibility, the interaction between pure rotational states of HCl and HF is discussed in detail. Barring unforeseen experimental difficulty (e.g., chemical activity

of HF) the Schawlow-Townes condition for maser action can be satisfied by the $J = 3 \rightarrow 2$ transition in HF at 123.1 cm^{-1} , or 81.25μ .

Welton, J. T.

W18 FREE-FLIGHT TELEMETRY TESTING IN THE JET PROPULSION LABORATORY WIND TUNNELS

Welton, J. T.

Technical Report No. 32-775, September 15, 1965
(Unclassified)

A program has been conducted in the Jet Propulsion Laboratory Hypersonic Wind Tunnel to develop an operational technique for obtaining interference-free base pressure data. The technique developed utilizes a pneumatic launch mechanism to project the models into free flight and an electronic transmitter and receiver system to obtain base pressure data from the model. Both 10- and 15-deg half-angle cone configurations were tested.

Whitaker, E. A.

W19 RANGER VIII AND IX.

PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS

Heacock, R. L., Kuiper, G. P., Shoemaker, E. M.,

Urey, H. C., Whitaker, E. A.

Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

White, A. B.

W20 PREDICTION OF HEAT TRANSFER FROM LAMINAR BOUNDARY LAYERS WITH EMPHASIS ON LARGE FREE-STREAM VELOCITY GRADIENTS AND HIGHLY COOLED WALLS

Back, L. H., White, A. B.

Technical Report No. 32-728, April 1, 1965
(Unclassified)

For abstract, see Entry B01.

Whitten, D. G.

W21 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES

Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.

Technical Report No. 32-713 (Unclassified)

(Reprinted from the *AAS Science and Technology Series*, Vol. 2, 1964, pp. 93-117)

For abstract, see Entry B14.

W22 PYROLYSIS STUDIES. CONTROLLED THERMAL DEGRADATION OF MESOPORPHYRIN

Whitten, D. G., Bentley, K. E., Kuwada, D.

Technical Report No. 32-812 (Unclassified)

(Reprinted from the *Journal of Organic Chemistry*, Vol. 31, 1966, pp. 322-324)

It was found that pyrolysis of porphyrins at $800\text{--}900^\circ$ caused extensive fragmentation of the porphyrin nucleus. The thermal decomposition of the porphyrin has been investigated under less drastic conditions than those previously reported. The major organic products obtained from thermal decomposition of mesoporphyrin at several temperatures over the range $400\text{--}780^\circ$ were the various alkylpyrroles. Small amounts of acetonitrile and propionitrile were obtained as well as moderate yields of methane, ethylene and ethane. This yield of hydrocarbons and nitriles increased with temperature. Thermal decomposition products of mesoporphyrin at lower temperatures ($400\text{--}600^\circ$) were the same as those formed in reductive degradation. As the temperature of pyrolysis was elevated, the yield of other less characteristic alkylpyrroles increased. The results of this work emphasize the utility of controlled pyrolysis as an adjunct to direct mass spectrometry.

Whittlesey, A. C.

W23 DESCRIPTION AND ANALYSIS OF 890-MHz NOISE-MEASURING EQUIPMENT

Biber, K. W., Whittlesey, A. C.

Technical Report No. 32-898, March 31, 1966
(Unclassified)

For abstract, see Entry B19.

Wiksten, D. B.

W24 DYNAMIC ENVIRONMENT OF THE RANGER SPACECRAFT: I THROUGH IX (FINAL REPORT)

Wiksten, D. B.

Technical Report No. 32-909, May 1, 1966 (Unclassified)

The dynamic environment of the *Ranger* spacecraft (I through IX) during the launch portion of flight is defined in this Report. Flight data from launches have been reviewed and are included. The environments include liftoff acoustics, liftoff and transonic vibration, and the transient vibrations of the various pyrotechnic and staging events in the launch sequence. Systems for data acquisition and analysis are described. Postflight comparison of flight data and ground test specification levels is made, and the dynamic test program is discussed.

Wilhite, W. F.

W25 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES

Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.

Technical Report No. 32-713 (Unclassified)

(Reprinted from the *AAS Science and Technology Series*, Vol. 2, 1964, pp. 93-117)

For abstract, see Entry B14.

**W26 DEVELOPMENTS IN MICRO-GAS
CHROMATOGRAPHY**

Wilhite, W. F.

Technical Report No. 32-805 (Unclassified)
(Reprinted from *Journal of Gas Chromatography*,
February 1966, pp. 47-50)

A micro-gas chromatographic system has been developed at the Jet Propulsion Laboratory to analyze the atmosphere of Mars in a few seconds during the descent of a landing capsule. The system consists of micro components, including highly efficient micro-packed columns capable of rapid separation at flow rates of less than 1 cc per minute, a micro-thermal conductivity detector with an internal volume of 0.1 μ l and sensitivity better than 5 ppm, and a sampling valve capable of injecting a 1- μ l gas sample. The components, and the new techniques required to develop them, are described.

Williams, H. E.

**W27 AN EVALUATION OF THE EFFECT OF FINITE
SHEAR STRAIN IN A SHALLOW, SPHERICAL SHELL**

Williams, H. E.

Technical Report No. 32-780, October 1, 1965
(Unclassified)

In an effort to assess the effect of including transverse shear strain in the analysis of thin shells, the equations proposed by E. Reissner are specialized for shallow, spherical shells and are solved for cases of loading for which the effect might be expected to be appreciable. It is found that, for materials that are nearly isotropic, the solution for an edge-loaded shell differs slightly from that of the classical equation. However, the solution in the neighborhood of a concentrated load applied at the apex is found to differ significantly from its classical counterpart.

Willingham, D.

W28 RANGER PHOTOMETRIC CALIBRATION

Smith, G. M., Willingham, D.

Technical Report No. 32-665, August 15, 1965
(Unclassified)

For abstract, see Entry S19.

**W29 A FIGURE OF MERIT MEASURING
PICTURE RESOLUTION**

Rindfleisch, T., Willingham, D.

Technical Report No. 32-666, September 1, 1965
(Unclassified)

For abstract, see Entry R20.

W30 EYES ON THE MOON

Smith, G. M., Vrebalovich, T., Willingham, D.

Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics*, Vol. 4,
No. 3, March 1966, pp. 74-82)

For abstract, see Entry S20.

Wood, C. S.

**W31 THE RATES OF SOME DEGENERATE
REARRANGEMENTS AS DETERMINED BY NUCLEAR
MAGNETIC RESONANCE SPECTROSCOPY**

Mallory, F. B., Manatt, S. L., Wood, C. S.

Technical Report No. 32-857 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society*, Vol. 87, No. 23, December 1965, pp. 5433-5438)

For abstract, see Entry M04.

Wu, C.-S.

**W32 TEMPERATURE RELAXATION IN A FULLY
IONIZED PLASMA**

Wu, C.-S., Klevans, E. H., Primack, J. R.

Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 6,
June 1965, pp. 1126-1133)

The times for relaxation of anisotropic ion or electron temperatures to isotropy, and for relaxation of different ion and electron temperatures to equilibrium, are calculated using the plasma kinetic equation including dynamic shielding. It is shown that, in contradiction to the results (or assumptions) of previous analyses, electron-ion interactions can be more important than interactions between particles of the same species in the relaxation of an anisotropic distribution. The meaning of relaxation time is discussed and a new time for relaxation is introduced for the problem of the relaxation of electron and ion temperatures that are initially greatly different. Detailed numerical computations are presented for various cases of special interest.

**W33 HIGH-FREQUENCY CONDUCTIVITY OF A PLASMA
IN QUASI-EQUILIBRIUM. II. EFFECT OF A
UNIFORM MAGNETIC FIELD**

Wu, C.-S.

Technical Report No. 32-821 (Unclassified)
(Reprinted from *The Physical Review*, Vol. 140, No. 1A,
October 1965, pp. A118-A129)

A general expression for high-frequency conductivity is derived to include the effect of an external magnetic field. The limit of large ion mass is also discussed. For the special case that the unperturbed plasma is in thermodynamic equilibrium, the result obtained in the present paper reduces immediately to that previously discussed by Oberman and Shure.

Zmuidzinas, J. S.

Z01 PARTICLE SYMMETRIES

Zmuidzinas, J. S.

Technical Report No. 32-797, November 1, 1965
(Unclassified)

A theory of particle symmetries is proposed based on general principles of quantum mechanics and special relativity. Starting with a modest generalization of the Poincaré group and using techniques of group theory and operator algebras,

it is shown how to construct composite-particle state vectors labeled by external (i.e., pertaining to space-time properties) and internal quantum numbers of physical significance. Macroscopic space time behaves in exactly the same manner under both the Poincaré group and its generalization, the augmented Poincaré group. It is found that there exists a hierarchy of groups, $Sp(1) \subset Sp(2) \subset Sp(3) \subset \dots$, which characterizes internal symmetries of the composite particles. These groups are all noncompact. However, it is

argued that *physical* particle states are characterized by the compact subhierarchy of unitary groups $U(1) \subset U(2) \subset U(3) \subset \dots$. Thus, it is shown that the essential features of fundamental-particle symmetries can be derived in a general way from basic properties of space-time. These results are believed to form a theoretical framework for attacking dynamical problems such as the correlation of masses and spins with internal quantum numbers furnished by the hierarchy of unitary groups.

Space Programs Summary

The *Space Programs Summary* is a six-volume, bimonthly summary report that documents the current project activities and supporting research and advanced development efforts conducted, or managed, by the Jet Propulsion Laboratory for the National Aeronautics and Space Administration space exploration programs. This publication provides the National Aeronautics and Space Administration, other elements of the government, major aerospace contractors, and colleges and universities with technical information concerning the various Jet Propulsion Laboratory programs and projects. An equally important purpose of the *Space Programs Summary* is to provide technical information to Jet Propulsion Laboratory employees and to act as a storage source of information for later use in Laboratory *Technical Reports*.

AB01 THE LUNAR PROGRAM

Space Programs Summary, Volume I (Confidential)
No. 37-34, (May 1 to June 30, 1965), July 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 31, 1965),
January 31, 1966
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966
No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume I is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Lunar Program; the projects covered are *Ranger* and *Surveyor*. The general areas included are conception, design, research, development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses.

AB02 THE PLANETARY-INTERPLANETARY PROGRAM

Space Programs Summary, Volume II (Confidential)
No. 37-34, (May 1 to June 30, 1965), July 31, 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 31, 1965),
January 31, 1966
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966
No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume II is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Planetary-Interplanetary Program; the projects covered are *Mariner* and *Voyager*. The general areas included are conception, design, research, development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses. Study efforts related to future projects are also reported.

AB03 THE DEEP SPACE NETWORK

Space Programs Summary, Volume III (Unclassified)
No. 37-34, (May 1 to June 30, 1965), July 31, 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 30, 1965),
January 31, 1966
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966

Volume III is a bimonthly summary report of the current facility-project activities that have application to the JPL/NASA Deep Space Network (DSN); the facilities covered are the Deep Space Instrumentation Facility, Space Flight Operations Facility, and the DSN Ground Communication System. The general subjects and areas included are (1) *facility* design, fabrication and assembly, and system testing, (2) *communication components and systems* conception, design, research, development, developmental testing, and engineering analysis, and (3) *tracking* conception, design, system testing, preflight and flight operations, and engineering analysis.

AB04 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT

Space Programs Summary, Volume IV (Unclassified)
No. 37-33, (April 1 to May 31, 1965), June 30, 1965
No. 37-34, (June 1 to July 31, 1965), August 31, 1965
No. 37-35, (August 1 to September 30, 1965),
October 31, 1965
No. 37-36, (October 1 to November 30, 1965),
December 31, 1965
No. 37-37, (December 1, 1965 to January 30, 1966),
February 28, 1966
No. 37-38, (February 1 to March 31, 1966), April 30, 1966

Volume IV is a bimonthly summary report of the current *unclassified* supporting research and advanced development

activities that have application to the JPL/NASA space exploration programs. The general subject areas include aerodynamics, celestial mechanics, chemistry, computers, electrical power supply, electronics, environmental simulators, exobiology, fluid flow, guidance and control, instrumentation, space sciences, materials, mathematics, microbiology, physics, polymers, propellants, propulsion systems, quality assurance and reliability, structural mechanics, telecommunications, test facilities, and thermodynamics and combustion.

AB05 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT

Space Programs Summary, Volume V (Confidential)

No. 37-34, (June 1 to July 31, 1965), August 31, 1965

No. 37-35, (August 1 to September 30, 1965),
October 31, 1965

No. 37-36, (October 1 to November 30, 1965),
December 31, 1965

No. 37-38, (February 1 to March 31, 1966), April 30, 1966

Volume V is a bimonthly summary report of the current *classified* supporting research and advanced development activities that have application to the JPL/NASA space exploration programs.

AB06 SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES

Space Programs Summary, Volume VI (Unclassified)

No. 37-34, (May 1 to June 30, 1965), July 31, 1965

No. 37-35, (July 1 to August 30, 1965),
September 31, 1965

No. 37-36, (September 1 to October 31, 1965),
November 30, 1965

No. 37-37, (November 1 to December 31, 1965),
January 31, 1966

No. 37-38, (January 1 to February 28, 1966),
March 31, 1966

No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume VI is a bimonthly publication consisting of: (1) an unclassified digest of appropriate material from Volumes I, II, and III; (2) a reprint of the space science instrumentation studies of Volumes I and II; and (3) beginning with *Space Programs Summary* No. 37-31, an original presentation of technical supporting activities, including engineering development of environmental-test facilities, and quality assurance and reliability. The purpose of this Volume is to present a brief, generalized report of activities especially suitable for distribution to the scientific community. Additional space science studies are reported in Volume IV.

Astronautics Information Literature Search

The Jet Propulsion Laboratory Library conducts extensive literature searching programs covering subjects selected by the technical staffs of the Laboratory to meet their particular research requirements. Those searches considered to be of interest to persons working in the field of astronautics are published for distribution to their respective organization.

**AC01 INTERACTIONS OF SPACECRAFT AND OTHER
MOVING BODIES WITH NATURAL PLASMAS**
Sterkin, C. K., Compiler
Literature Search No. 541, December 1965
(Unclassified)

Recent space exploration has provided data on the interactions of a moving spacecraft (satellite, rocket or missile) with the surrounding ionized medium—ionosphere, magnetosphere, or interplanetary plasma. The practical aspects of the complex and interrelated electrical and magnetic phenomena are of pri-

mary interest. These include electrical hazards to spacecraft; effects on spacecraft communications, tracking and detection; effects on measurement of environmental plasma parameters.

This search has been prepared at the request of personnel at the Jet Propulsion Laboratory. Although most of the references presented (approximately two-thirds) concern spacecraft phenomena and related ionospheric instrumentation and data, the search also includes literature on interactions of other types of moving man-made bodies and on similar natural phenomena.

JPL Reporting in the Open Literature

This section lists engineering and scientific articles by JPL technical personnel which have been published in the open literature — either domestic or foreign. Articles from the open literature which have been reprinted and published as JPL Technical Reports are included in the preceding section, "Technical Reports and Memorandums."

Aller, L. H.

**AD01 PHOTOELECTRIC SPECTROPHOTOMETRY OF
SELECTED SOUTHERN STARS**

Aller, L. H., Faulkner, D. J., Norton, R. H.
Astrophysical Journal, Vol. 140, November 15, 1964
pp. 1609-1612

As part of an extensive spectrophotometric program on stars, gaseous nebulae, and clusters carried out at Mount Stromlo Observatory, Canberra, Australia, the energy distributions of a number of southern stars have been measured. A photoelectric spectrum scanner was used. Observations of a southern star over a wide range of zenith distances permitted a determination of the atmospheric extinction. Northern or equatorial-zone stars with previously determined energy distributions served as standards for the energy distributions of these southern stars. On a given night, several program stars and northern standard stars could be observed, making possible not only intercomparisons between program and standard stars, but also between the standard stars themselves.

Back, L. H.

**AD02 COMPARISON OF MEASURED AND PREDICTED
FLOWS THROUGH CONICAL SUPERSONIC
NOZZLES, WITH EMPHASIS ON THE
TRANSONIC REGION**

Back, L. H., Massier, P. F., Gier, H. L.
AIAA Journal, Vol. 3, No. 9, September 1965,
pp. 1606-1614

To understand better equilibrium flows through supersonic nozzles, wall static pressures have been measured in nozzles with circular-arc throats having different ratios of throat radius of curvature to throat radius r_c/r_{th} , circular-arc or conical convergent sections, and conical divergent sections. These measurements were made with air at stagnation temperatures of 530 and 1500°R and over a stagnation pressure range from 45 to 250 psia. The flow through the transonic region was found to depend essentially on local configuration, i.e., on the ratio r_c/r_{th} ; two-dimensional isentropic flow predictions agreed with the data in this region for the nozzles with $r_c/r_{th} = 2.0$, but were inadequate for the nozzle with $r_c/r_{th} = 0.625$. By comparison, the simple one-dimensional isentropic flow prediction was as much as 45% high in the throat region for one

nozzle; in the conical sections, deviations of a smaller magnitude were found. The effects of wall cooling and variation in the boundary-layer thickness at the nozzle inlet were investigated, as were differences in pressure readings with taps of various sizes. Some separation pressure data are presented to show the effect of wall cooling. Other flow features that indicate the extent of deviations from one-dimensional flow include flow coefficients, thrust ratios, and local mass fluxes. It is hoped that these comparisons between measurements and predictions will be useful in studying nozzle flows with the additional complexity of chemical reactions.

Baumert, L. D.

**AD03 HADAMARD MATRICES OF THE WILLIAMSON
TYPE**

Baumert, L. D., Hall, M., Jr.
Mathematics of Computation, Vol. 19, No. 91, July 1965,
pp. 442-447

Tabulation of all the known Hadamard matrices of the Williamson type for $n = 4t$ (t odd). Since a Hadamard matrix of an order $2n = 2(4t)$ can be easily constructed from one of order n , the question of existence for all possible orders can be reduced to the case where t is odd. Thus it is noted that Hadamard matrices having the additional structure imposed by Williamson exist for all odd values of $5 \leq t \leq 27$ and, in particular, that this includes every value of t for which an exhaustive search has been performed.

AD04 BACKTRACK PROGRAMMING

Golomb, S. W., Baumert, L. D.
Journal of the Association for Computing Machinery,
Vol. 12, No. 4, October 1965, pp. 516-524

For abstract, see Entry AD16.

AD05 HADAMARD MATRICES OF ORDERS 116 AND 232
Baumert, L. D.

Bulletin of the American Mathematical Society, Vol. 72,
No. 2, March 1966, p. 237

A Hadamard matrix H is a square matrix of ones and minus ones whose row (and hence column) vectors are orthogonal.

The order n of a Hadamard matrix is necessarily 1, 2, or $4t$, for some positive integer t . It has been conjectured that this condition ($n = 1, 2$ or $4t$) also insures the existence of a Hadamard matrix. Constructions have been given for particular values of n and even for various infinite classes of values. In that note a Hadamard matrix of order 116, the smallest unsolved case is constructed. Taking the tensor product of this matrix with the Hadamard matrix of order 2 yields a Hadamard matrix of order 232, also previously unsolved. This leaves $n = 188$ as the only unknown case less than 200.

Beaudet, R. A.

AD06 MICROWAVE SPECTRUM, ISOMERIC FORM, DIPOLE MOMENT OF 1,1-DIFLUOROBUTADIENE

Beaudet, R. A.

The Journal of Chemical Physics, Vol. 42, No. 11, June 1, 1965, pp. 3758-3760

The microwave spectrum of 1,1-difluorobutadiene has been studied. The small inertial defect indicates that the molecule is planar. From the allowed transition selection rules and the magnitudes of the moments of inertia, the molecule is shown to exist predominantly as the *trans* isomer. Attempts to find the spectrum of the *cis* were unsuccessful.

Chen, C. J.

AD07 COMMENTS ON "VISIBLE CONTINUUM EMISSION FROM SHOCKED NOBLE GASES"

Chen, C. J.

The Physics of Fluids, Vol. 8, No. 8, August 1965, pp. 1573-1574

The expression for the intensity of electron-ion recombination continuum radiation from a plasma by calculating the coefficient of absorption of a photon interacting with atoms and using the radiational equilibrium argument to get the intensity of radiation has been derived by Kramers and Unsöld. In such an approach the number density of the atoms n_a will appear in the expression for the radiation and the electron density n_e is introduced by eliminating n_a through the use of the Saha equation. The conditions required for the Saha equation to be valid, stated in Griem's paper, are that the plasma be in complete local thermodynamic equilibrium. These conditions usually cannot be expected in most laboratory plasmas. However, the electron-ion recombination continuum intensity theory can be formulated by using the free-bound transition probability of an electron, integrating over all possible electron velocities and summing over only the energy states contributing to the continuum radiation at a given frequency. The assumption made in such a calculation is that the energy of the free electrons have Maxwellian distribution, and the ions are in the ground states. The problem is then reduced to that of a hydrogen-like plasma.

Dayman, B., Jr.

AD08 HYPERSONIC VISCOUS EFFECTS ON FREE-FLIGHT SLENDER CONES

Dayman, B., Jr.

AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1392-1400

An experimental study was performed in order to determine the effects of various parameters upon cone aerodynamics in the hypersonic regime at Reynolds numbers as low as 7800/in. The use of free-flight models eliminated the need for evaluating sting interference and made practical accurate measurement of drag forces down to 8×10^{-4} lb and pitching moments as low as 2×10^{-4} in.-lb. The effects of model to total temperature ratios of 0.45 (gun launch) and 0.87 (wire release) for 6 through 15° half-angle cones on total drag and static stability were investigated at Mach numbers from 6 to 10 for values of the viscous Knudsen number up to $M_\infty/(R_{D\infty})^{1/2} = 0.28$. Limited nose-blunting effects were also investigated. Conical shock viscous drag theory agrees quite favorably with the experimental data. Use is made of trends predicted by theory in order to compare the data of this paper with available hypersonic viscous cone drag data.

Elliott, D. G.

AD09 DIRECT CURRENT LIQUID-METAL MAGNETOHYDRODYNAMIC POWER GENERATION

Elliott, D. G.

AIAA Journal, Vol. 4, No. 4, April 1966, pp. 627-634

A constant-pressure dc magnetohydrodynamic generator was tested with NaK at inlet velocities up to 300 ft/sec. The maximum output power was 10.8 kw (18,250 amp at 0.59 v), and the efficiency was 48%. The theoretical efficiency, considering ohmic heating, fluid friction, boundary-layer shunting, and end effects, was 58%. The theoretical ultimate efficiency of liquid-metal MHD generators, of the type considered, ranges from 60 to 70%.

Faulkner, D. J.

AD10 PHOTOELECTRIC SPECTROPHOTOMETRY OF SELECTED SOUTHERN STARS

Aller, L. H., Faulkner, D. J., Norton, R. H.

Astrophysical Journal, Vol. 140, November 15, 1964, pp. 1609-1612

For abstract, see Entry AD01.

Forney, R. G.

AD11 RANGER VII, A NEW SPACE INSTRUMENT

Forney, R. G., Kindt, D. H., Kirhofer, W. E., Schurmeier, H. M., Wolfe, A. E.

Astronautica Acta, Vol. 11, No. 1, Springer-Verlag, New York, 1965, pp. 13-35

This paper describes some of the characteristics of the basic *Ranger* system and what considerations were involved in deter-

mining these specific characteristics. The design and performance of several of the key subsystems are covered in some detail. In addition to explaining how the spacecraft is used, the flight of *Ranger VII* is described along with the results that were obtained.

Fowle, A. A.

- AD12 THERMAL SCALE MODELING OF SPACECRAFT:
AN EXPERIMENTAL INVESTIGATION**
Fowle, A. A., Gabron, F., Vickers, J. M. F.
Journal of Spacecraft and Rockets, Vol. 3, No. 4,
April 1966, pp. 577-581

A one-half and a one-fifth scale model of the prototype were built and tested within a "cold-wall" vacuum chamber to examine the applicability of a set of thermal modeling laws which specifies different materials of construction to achieve identical temperatures at homologous locations in model and prototype. Another one-half scale model was built and tested to examine the application of another set of thermal modeling laws which allows the use of identical materials but predicts different temperature fields in model and prototype. The experimental results proved that either a half-scale thermal model could be used to predict the temperatures of the prototype configuration with an accuracy of approximately 1% (3°C) of the absolute temperature level of the prototype, or temperatures of the one-fifth scale thermal model could be predicted to within 3% (10°C), which represents a 14% error in T^4 for radiant energy exchange.

Gabron, F.

- AD13 THERMAL SCALE MODELING OF SPACECRAFT:
AN EXPERIMENTAL INVESTIGATION**
Fowle, A. A., Gabron, F., Vickers, J. M. F.
Journal of Spacecraft and Rockets, Vol. 3, No. 4,
April 1966, pp. 577-581

For abstract, see Entry AD12.

Gier, H. L.

- AD14 COMPARISON OF MEASURED AND PREDICTED
FLOWS THROUGH CONICAL SUPERSONIC
NOZZLES, WITH EMPHASIS ON THE
TRANSONIC REGION**
Back, L. H., Massier, P. F., Gier, H. L.
AIAA Journal, Vol. 3, No. 9, September 1965,
pp. 1606-1614

For abstract, see Entry AD02.

Goldstein, R. M.

- AD15 MARS: RADAR OBSERVATIONS**
Goldstein, R. M.
Science, Vol. 150, No. 3704, December 24, 1965,
pp. 1715-1717

Radar studies of Mars indicate that certain areas are quite smooth. Rough, strongly reflecting regions have also been found, as well as poorly reflecting ones. Mars as a whole is significantly smoother to radiation of 12.5-centimeter wavelength than Venus.

Golomb, S. W.

- AD16 BACKTRACK PROGRAMMING**
Golomb, S. W., Baumert, L. D.
Journal of the Association for Computing Machinery,
Vol. 12, No. 4, October 1965, pp. 516-524

A widely used method of efficient search is examined in detail. This examination provides the opportunity to formulate its scope and methods in their full generality. In addition to a general exposition of the basic process, some important refinements are indicated. Examples are given which illustrate the salient features of this searching process.

Gray, L. D.

- AD17 CALCULATIONS OF ATMOSPHERIC RADIATION
FROM 4.2μ TO 5μ**
Gray, L. D., McClatchey, R. A.
Applied Optics, Vol. 4, No. 12, December 1965,
pp. 1624-1631

In the $4.2\text{-}\mu$ to $5\text{-}\mu$ region of the spectrum, the absorption in the Earth's atmosphere is primarily due to the $4.3\text{-}\mu$ bands of CO_2 , the $4.6\text{-}\mu$ bands of N_2O , and the $4.7\text{-}\mu$ bands of CO . These minor constituents appear to be uniformly distributed in the atmosphere. As a result, the absorption in a small frequency interval can be written as a function of atmospheric pressure and temperature. The spectral absorption is calculated for homogeneous absorber path lengths representative of various heights in the telluric atmosphere. Application of the Curtis-Godson approximation allows the calculations to be extended to real, nonhomogeneous atmospheric paths. The spectral energy distribution of the radiation passing through various isobaric levels of the Earth's atmosphere is presented for several model atmospheres. The quasi-statistical band model is used to compute the spectral absorption in the region 2000 cm^{-1} to 2400 cm^{-1} at intervals of 5 cm^{-1} . A normal abundance of isotopic molecules is assumed and a total of ninety-nine vibrational transitions are considered. Spectral absorption computed for the individual molecules is shown to be in good agreement with laboratory data.

Hall, M., Jr.

- AD18 HADAMARD MATRICES OF THE WILLIAMSON
TYPE**
Baumert, L. D., Hall, M., Jr.
Mathematics of Computation, Vol. 19, No. 91, July 1965,
pp. 442-447

For abstract, see Entry AD03.

Harding, J. T.

AD19 DENSITY OF NIOBIUM

Harding, J. T.

Journal of Applied Physics, Vol. 37, No. 2,
February 1966, p. 928

Values of the density of niobium as reported in the literature and in standard reference texts differ by 2% or more. These discrepancies are due to purity variations and porosity in all niobium available until recently; high-temperature, high-vacuum outgassing of niobium is presently capable of producing niobium with consistent mechanical properties. Data are given here for the density of six niobium spheres which are intended for use as rotors in a superconducting gyroscope.

Kindt, D. H.

AD20 RANGER VII, A NEW SPACE INSTRUMENT

Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.

Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13-35

For abstract, see Entry AD11.

Kirhofer, W. E.

AD21 RANGER VII, A NEW SPACE INSTRUMENT

Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.

Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13-35

For abstract, see Entry AD11.

Kotlensky, W. V.

**AD22 TENSILE PROPERTIES OF GLASSY CARBON
TO 2,900 deg C**

Kotlensky, W. V., Martens, H. E.

Nature, Vol. 206, No. 4990, June 19, 1965, pp. 1241-1247

Glassy carbon is a turbostrate form of carbon. Tensile properties of two grades of glassy carbon called GC 20 GC 30 have been measured from room temperature to 2,900°C. Specimens were heated in an inert atmosphere to test temperature by means of an external graphite heater; the ultimate tensile strengths are not markedly different.

Fracture elongations at 2,500°C and above is markedly greater for GC 20 than for GC 30. The difference is due to cyclic heat treatment. Tensile properties of carbons and graphites are closely associated with structures and processing. Heat treatment on GC 20 showed a growth in crystallite diameter; changes in crystallite diameter were qualitatively confirmed by magnetic susceptibility measurements. These results suggest that non-graphitizing behavior and strong cross-link bonding give glassy carbon its good strength properties.

Lardner, T. J.

**AD23 STRESSES IN A THICK PLATE WITH AXIALLY
SYMMETRIC LOADING**

Lardner, T. J.

The Journal of Applied Mechanics, Transactions of ASME, Series E, Vol. 32, No. 2, June 1965, pp. 458-459

The problem of the thick elastic plate with a symmetric circular pressure loading is considered. The normal stress distribution on the midplane and for two positions off the midplane is obtained by a numerical integration of the solutions. A comparison of the stress distribution on the midplane is made with previous results.

Lindsey, W. C.

**AD24 CODING FOR SPECULAR AND SCATTER
CHANNELS**

Lindsey, W. C.

IEEE Transactions On Communication Technology,
Vol. COM-13, No. 2, June 1965, pp. 237-238

Briefly, systems are considered which transmit one of $N = 2^n$ orthogonal equiprobable, equi-energy, narrow-band waveforms of duration $T = nT_b$ seconds into a single-link channel perturbed by slowly varying Rician fading and statistically independent white Gaussian noise of single-sided spectral density $N_0 W/(c/s)$. On reception, one of two (coherent or noncoherent) receivers is used to process the observed data.

Results are presented which were derived in Lindsey for $n = 1$, i.e., binary transmission and coherent reception. For a given γ^2 , the limiting cases $n = 1$ and $n = \infty$ show the possible reduction in transmitter power which could ultimately be achieved by coding. Comparison of the two sets of curves indicates that coding is more effective in channels whose specular components are large when compared to the mean-squared value of the scatter component. For channels which are largely scatter in nature, i.e., $0 < \gamma^2 < 2$, improvement achieved by coding is relatively small. Given a value for the total average received SNR, $(1 + \gamma^2)\beta$ per bit of transmitted information and a value for γ^2 , one may determine the ultimate gain in signal power relative to the noise (or equivalently the reduction in error probability) resulting from coding.

Similar results could be given for $N = 2$ and the noncoherent detector; however, it may be shown that, even though the coherent detector performance is bounded from above by that for noncoherent detection, the same general conclusions may be reached.

**AD25 ERROR PROBABILITY FOR INCOHERENT
DIVERSITY RECEPTION**

Lindsey, W. C.

IEEE Transactions on Information Theory, Vol. IT-11,
No. 4, October 1965, pp. 491-499

The problem of computing error probabilities for multichannel communications using an incoherently terminated receiver is analyzed. The signaling alphabet is composed of two equal energy, equiprobable, correlated waveforms and the multichannel model is presumed to be of the slowly fading "Rician" type, i.e., each subchannel is presumed to be composed of a fixed or specular component and a scatter-like or Rayleigh fading component. The main result of this paper is a generalization of an earlier result derived by Helstrom. Novel by-products of this generalization include, as special cases, results derived by Turin, Pierce, Price, and Lindsey. Also closed-form solutions to very general integrals involving Bessel function products are presented as part of the main result. These integrals are known to arise in the analysis of multichannel adaptive communication systems.

Numerical computations for the error probabilities are given for special values of the signal cross-correlation coefficient λ and multichannel order. These results graphically illustrate that the optimum set of equal-energy binary signals which minimize the error rate for the Rayleigh fading multichannel are orthogonal. Specifically, to maintain the same error probability in two systems, one employing nonorthogonal signals having correlation coefficient λ , the other employing orthogonal signals, the transmitter power must be increased in the former. In fact, for large SNR's, the graphical data indicate that the required increase in transmitter power is approximately $10 \log_{10} (1 - \lambda^2)^{-1}$ dB.

Loomis, A. A.

AD26 INTERPRETATION OF LUNAR ALPHA-SCATTERING DATA

Loomis, A. A.

Journal of Geophysical Research, Vol. 70, No. 16, August 15, 1965, pp. 3841-3849

Many ambiguities are inherent in the interpretation of chemical analyses if such analyses are used alone to interpret a rock genetically. Furthermore, rocks at the surface of the Moon may differ from rocks below the surface because of contamination by meteoritic infall, bombardment by charged particles, and extensive mixing by impact. Nevertheless, the broad categories of igneous rocks and meteorites which are familiar on the Earth are the best compositional models for rocks on the Moon. Anhydrous igneous rocks and meteorites may be categorized on the basis of the atomic percentage of oxygen: (1) below 50%, sputtered rocks and those with free metal in excess of that in chondrites; (2) 50 to 56%, chondritic meteorites; (3) 57 to 58½%, dunites and olivine-rich peridotites; (4) 58½ to 60%, peridotites and pyroxenites; (5) 60 to 61%, basalts, some alkalic derivatives; (6) 61 to 64%, siliceous derivatives, some alkalic rocks. The Si/Na ratio is another reliable chemical parameter on which to base further subdivisions of genetic importance; terrestrial anhydrous igneous rocks and meteorites occupy well-defined fields in a plot of oxygen percentage versus Si/Na. The best parameter

for resolving ambiguities in such a plot is the Mg/Si ratio. The concurrence of high Mg/Si and Mg/Na ratios with oxygen contents of over 59 to 60% will indicate water in the sample. The amount of water can be estimated by balancing the cations and anions in the actual analysis.

Martens, H. E.

AD27 TENSILE PROPERTIES OF GLASSY CARBON TO 2,900 deg C

Kotlensky, W. V., Martens, H. E.

Nature, Vol. 206, No. 4990, June 19, 1965, pp. 1241-1247

For abstract, see Entry AD22.

Massier, P. F.

AD28 COMPARISON OF MEASURED AND PREDICTED FLOWS THROUGH CONICAL SUPERSONIC NOZZLES, WITH EMPHASIS ON THE TRANSONIC REGION

Back, L. H., Massier, P. F., Gier, H. L.

AIAA Journal, Vol. 3, No. 9, September 1965, pp. 1606-1614

For abstract, see Entry AD02.

McClatchey, R. A.

AD29 CALCULATIONS OF ATMOSPHERIC RADIATION FROM 4.2μ TO 5μ

Gray, L. D., McClatchey, R. A.

Applied Optics, Vol. 4, No. 12, December 1965, pp. 1624-1631

For abstract, see Entry AD17.

Melbourne, W. G.

AD30 CONSTANT-ATTITUDE THRUST PROGRAM OPTIMIZATION

Melbourne, W. G., Sauer, C. G., Jr.

AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1428-1431

The analysis for the optimization of a space vehicle thrust program with prespecified directions of thrust is presented. The criteria for optimizing the values of the prespecified thrust directions are also developed. A numerical comparison in vehicle performance is made between a constant-attitude thrust program and the optimum variable direction program by means of a series of Earth-Mars rendezvous and flyby trajectories, using a power-limited propulsion system. The sensitivity of vehicle performance to departures in thrust direction from the optimum prespecified direction is discussed. It is shown that a constant-attitude thrust program with two or more optimized thrust directions is competitive in vehicle performance with the variable direction program for typical interplanetary missions.

Münch, G.

- AD31 VISIBLE AND NEAR-INFRARED
SPECTROPHOTOMETRY OF SATURN'S RINGS
Younkin, R. I., Münch, G.
The Astronomical Journal, Vol. 71, No. 3, April 1966,
No. 1338, p. 188

For abstract, see Entry AD60.

Nash, D. B.

- AD32 PROTON-EXCITED LUMINESCENCE OF
SILICATES: EXPERIMENTAL RESULTS
AND LUNAR IMPLICATIONS
Nash, D. B.
Journal of Geophysical Research, Vol. 71, No. 10,
May 15, 1966, pp. 2517-2534

Spectral energy distributions and excitation efficiencies as functions of mineral composition, irradiation time, proton energy, proton flux, sample geometry, and sample temperature have been determined from laboratory measurements of silicate luminescence by low-energy proton excitation. The maximum of the luminescence spectrum of many silicates under continuous excitation by 5-keV protons is in the red when the mineral is first excited; the luminescence intensity decreases, and the maximum shifts from red to blue with time. This phenomenon is here described as a red flash. After the initial red flash, a second flash, subsequent intensity decay, and blue shift can be produced by a sudden increase of incident ion energy. In both cases the red flash has a principal decay period of about 15 to 20 min. The intensity of both the flash and aged luminescence response is directly proportional to incident ion energy and flux. Small particle size for powders, high roughness for solid surfaces, and low mineral temperature favor high luminescence intensity. These data qualitatively agree with the concept of solar-ion excitation as the origin of reported transient lunar reddening near Aristarchus and Kepler. However, these measurements show that the energy efficiency for proton excitation of silicate luminescence is between 10^{-4} and 10^{-6} ; this range is several orders of magnitude lower than values previously reported. In view of the known solar-ion flux, the low efficiencies indicate that luminescence on the sunlit lunar surface resulting from solar-ion excitation is far below the sensitivity of earth-based detection apparatus and that other energy sources or other explanations for the origin of lunar color flashes must be sought.

Newburn, R. L., Jr.

- AD33 FURTHER STUDIES OF THE INFRARED SPECTRA
OF COOL STARS, THE WATER DEFICIENCY IN
S STARS AND VARIATION OF WATER
ABUNDANCE WITH MIRA'S PHASE
Spinrad, H., Pyper, D. M., Newburn, R. L., Jr.,
Younkin, R. L.
The Astrophysical Journal, Vol. 143, No. 2,
February 1966, pp. 291-298

For abstract, see Entry AD45.

Nishimura, T.

- AD34 ON THE A PRIORI INFORMATION IN
SEQUENTIAL ESTIMATION PROBLEMS
Nishimura, T.
Proceedings of the National Electronics Conference,
Vol. 21, 1965, pp. 511-515

The optimal filter introduced by Kalman into the field of system theory yields the minimum variance estimate of states of linear systems, which are contaminated by white gaussian noises, when a set of sequential observations is carried out. The original theory assumes an *a priori* information of the initial states and their variances. Soong examined the effect of the error in the *a priori* data on the *a posteriori* variance of estimates for the case of a single-stage observation and derived the deviations of the calculated and actual variances from the true minimum variance.

In this paper, the same problem is studied for the multi-stage case. Then this optimal filter is connected to the existing analog filter in tandem. By means of this tandem configuration of analog filter and digital filter, the detection of states as well as signals can be speeded up. A phase-locked loop receiver is used as an example of the analog filter. The practical importance of the extended results on the effect of errors in the *a priori* information is demonstrated in a specific example.

The effect of errors in the *a priori* information has been investigated for the sequential estimation problem, and the three theorems which specify the mutual relations among the three covariance matrices P_o , P_e , and P_a have been derived. The phase-locked loop receiver is picked up as an example of analog filter, for which a suitable digital filter is designed. The technique developed in this paper is useful for the estimation problem of deterministic signals in the presence of stochastic noise. Although the signal (phase) input has been treated as a state in this analysis, it is possible to describe the input contribution in an explicit form.

Norton, R. H.

- AD35 PHOTOELECTRIC SPECTROPHOTOMETRY OF
SELECTED SOUTHERN STARS
Aller, L. H., Faulkner, D. J., Norton, R. H.
Astrophysical Journal, Vol. 140, November 15, 1964,
pp. 1609-1612

For abstract, see Entry AD01.

Patapoff, M.

- AD36 VALIDITY AND LIMITATIONS OF THE GAS
TITRATION OF ATOMIC NITROGEN WITH
NITRIC OXIDE
Von Weyssenhoff, H., Patapoff, M.
The Journal of Physical Chemistry, Vol. 69, No. 5,
May 1965, pp. 1756-1758

For abstract, see Entry AD52.

Pfeiffer, C.

AD37 ON THE SEQUENTIAL ESTIMATION TECHNIQUE

Pfeiffer, C.

IEEE Transactions On Automatic Control, Vol. AC-11,
No. 1, January 1966, pp. 132-133

Recent work in linear filtering and prediction theory has been based upon the postulated existence of a linear dynamic model of the stochastic process being observed, with white-noise disturbances to the systems and white-noise measurement errors. With this model it is possible to explicitly construct the filter in terms of the given system parameters, and, hence, to solve some important practical problems with an elegant sequential estimation technique. The result is not the most general form of the linear, unbiased, minimum variance (LUMV) estimate, since all stochastic processes cannot be represented by such a model. Thus, in those applications where there is given only an empirical description of the statistics of the stochastic process to be observed, which would normally consist of numerical results obtained from an ensemble of system tests, two questions arise when it is sought to design an optimal linear filter:

1) Under what conditions does it make sense to employ a sequential estimation technique, similar to the Kalman-Bucy approach?

2) How does one construct the estimation equation from empirical test data?

It is the purpose of this correspondence to describe an analysis of the estimation problem which at least partially resolves these questions.

Pickering, W. H.

AD38 SOME NEW METHODS FOR PLANETARY EXPLORATION

Pickering, W. H.

Proceedings of the National Academy of Sciences,
Vol. 54, No. 6, December 1965, pp. 1471-1479

Exploration of the solar system has entered a new era. This paper is concerned primarily with two new tools for planetary research. The two examples discussed — planetary radar experiments from the Earth and spacecraft experiments at other planets—offer spectacular opportunities for investigating our neighboring planets.

Radar experiments show: (1) that solar system geometrical relationships are determined with extreme accuracy, and (2) that extensive new information on planetary surfaces is obtained to supplement that from observations with visible or infrared light.

Unmanned spacecraft traveling to the planets have demonstrated that complex experiments operate successfully at planetary distances. Information which can be obtained includes: (1) detailed trajectory analysis which makes possible more precise determinations of solar system parameters, such as the masses of the planets; (2) actual close-up observations

of the planets; and (3) data from instruments landed on the planet. Although this last has not been demonstrated, the results from *Mariner* give every indication this type of mission can succeed.

Pyper, D. M.

AD39 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCY IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE

Spinrad, H., Pyper, D. M., Newburn, R. L., Jr.,
Younkin, R. L.

The Astrophysical Journal, Vol. 143, No. 2,
February 1966, pp. 291-298

For abstract, see Entry AD45.

Sauer, C. G., Jr.

AD40 CONSTANT-ATTITUDE THRUST PROGRAM OPTIMIZATION

Melbourne, W. G., Sauer, C. G., Jr.

AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1428-1431

For abstract, see Entry AD30.

Schurmeier, H. M.

AD41 RANGER VII, A NEW SPACE INSTRUMENT

Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.

Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13-35

For abstract, see Entry AD11.

Scull, J. R.

AD42 GUIDANCE AND CONTROL OF THE MARINER PLANETARY SPACECRAFT

Scull, J. R.

Ékspress-informatsiya, Astronavtika i raketodinamika,
No. 41, November 3, 1965, Moscow, pp. 325-331

(Paper presented at the Symposium of the International
Federation of Automatic Control on the Peaceful Uses
of Space, Stavanger, Norway, June 21-24, 1965)

The unmanned exploration of the Moon and nearby planets imposes very significant requirements on the guidance and control system of both the booster rocket and the spacecraft. The booster rocket must be launched into a narrow, moving corridor with great precision within a limited period of time. After separation, the spacecraft must be capable of providing corrections to the trajectory and controlling the orientation of solar panels, antennas, and scientific instruments.

The guidance and control systems of the *Mariner* planetary spacecraft are described. Some of the techniques developed to provide redundant operation during the long interplanetary flight are discussed. Flight performance of the *Mariner* guidance and control systems is reported.

Sehgal, R.

AD43 LOW-PRESSURE COMBUSTION OF SOLID PROPELLANTS

Sehgal, R., Strand, L.

AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1524-1525

Experimental studies conducted with polyurethane-type composite propellants indicated that the extinction pressure, although independent of the burning geometry, was strongly dependent upon motor L and certain other parameters, such as the aluminum concentration in the propellant. For non-aluminized propellants, the slope of L vs extinction pressure (P_e) was $-2n$ as predicted theoretically; however, the slope became steeper with the addition and increased concentration of aluminum in the propellant.

Some of the conclusions, which can be drawn from the various phases of the experimental program conducted at JPL can be summarized briefly as follows: (1) for a given propellant, the L vs extinction pressure relationship is a valid parameter for determining the low-pressure stable combustion limit; (2) for nonaluminized propellant, the slope of L vs P_e is $-2n$, as predicted theoretically for critical pressure; (3) the slope of L vs P_e relationship is affected by the presence of Al, the concentration of Al, and the Al particle size in propellant; (4) the effect of coarser Al in propellant is to cause incomplete combustion at low pressures, and the burning and extinction characteristics tend to approach those of non-aluminized propellant; and (5) the variation in oxidizer particle size has a negligible effect on the L vs P_e relationship; the small differences in extinction pressure at a given L are attributed to the variation in packing density.

Sjogren, W. L.

AD44 RESULTS ON PHYSICAL CONSTANTS AND RELATED DATA FROM THE RADIO TRACKING OF MARINER (VENUS) AND RANGER III-VI MISSIONS

Sjogren, W. L., Trask, D. W.

Journal of Spacecraft and Rockets, Vol. 2, No. 5, September-October 1965, pp. 689-697

The "real-time" flight-path analysis and performance are described for *Ranger VI* and *VII* missions. Over a large region of injection points for a *Ranger* mission, the midcourse maneuver can be based on an orbit with a 10-30 km uncertainty in the impact parameter B plane. The main problem in orbit determination is to obtain verification of data consistency between stations. As *Ranger VI* results show, small errors can perturb the orbit well beyond the 1-sigma target uncertainties. The *Ranger VII* photographs demonstrated that the impact point agreed to within 3 km. The predicted and observed impact times agreed to within 0.1 sec. The doppler measurements gave a real-time verification that the maneuver execution errors on *Ranger VI* and *VII* were well within design specifications. Determination of physical constants from earth-based radio tracking has resulted in improved knowl-

edge of the mass of the Moon of one order of magnitude and a factor of 4 for the Earth. Station locations can be determined to 10 m in the radial direction normal to the Earth's spin axis and in longitude differences to 20 m. The lunar radius at the impact points was determined to ± 0.3 km and in both cases was found to be approximately 3 km less than the previously accepted value.

Spinrad, H.

AD45 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCIES IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE

Spinrad, H., Pyper, D. M., Newburn, R. L., Jr., Younkin, R. L.

The Astrophysical Journal, Vol. 143, No. 2, February 1966, pp. 291-298

Low-dispersion near-infrared spectra of a variety of cool stars were obtained at the Kitt Peak National Observatory. The late-type S stars seem definitely deficient in water vapor compared to M giants of the same temperature. The spectral characteristics of the S stars in the infrared seem best explained by a slightly lower atmospheric O/C ratio than is found for normal M stars.

The variation of the strength of the λ 9400 water band in the spectrum of Mira during its light cycle seems to be in the direction expected from the known photospheric temperature changes. The water lines may have been stronger at the 1963 minimum than at corresponding 1964 phases.

AD46 INFRARED BANDS OF VANADIUM OXIDE IN THREE MIRA STARS

Spinrad, H., Younkin, R. L.

Publications of the Astronomical Society of the Pacific, Vol. 78, No. 460, February 1966, pp. 66-67

The purpose of this note is to illustrate the extremely large range in the strength of the λ 10,500 series of vanadium oxide bands in the near-infrared spectra of the coolest stars.

The infrared vanadium oxide bands were observed first in α Ceti and R Leonis by Kuiper, Wilson, and Cashman (1947) using a PbS detector. They have been observed photographically in these two stars and other Mira variables, generally near their light minima, by Miller (1953), McKellar (1955, 1956), and Frederick (1961). All these measurements were at low dispersion. The VO head wavelengths quoted by McKellar are $\lambda\lambda$ 10,459, 10,484, 10,510, 10,547, and 10,566; the bands degrade to the red.

Stearns, J. W., Jr.

AD47 TEST REQUIREMENTS OF ELECTRIC PROPULSION SYSTEMS LEADING TO EXTENDED FLIGHT TIME MISSIONS

Stearns, J. W., Jr.

Low-thrust characteristics of electric propulsion result from system power limitations. Optimized low-thrust flight trajectories require large thrust periods, culminating in less efficient trajectories than high-impulse trajectories. Because of this, the most useful electric propulsion missions are high-energy, high-specific-impulse missions, characterized by extended mission times, typically in the range of 5000 to 50,000 hr.

Like other forms of propulsion, the electric propulsion system includes a primary power source. The primary electrical powerplant has a strong influence on electric propulsion spacecraft applications because it represents the largest weight and structure in the spacecraft system. Utilizing electric propulsion for space exploration without a light-weight compact power source is not feasible. Results of trajectory analyses show that electric propulsion becomes potentially useful for planetary missions when the combined weight of primary power and propulsion system is less than 100 lb/kwe. Application of electric propulsion is limited, however, until total system weight is reduced to less than 50 lb/kwe.

Electric propulsion performance exceeds that of chemical propulsion when mission flight time approaches 10,000 hr. Thus, a 10,000-hr lifetime is a reasonable goal for initial development of electric propulsion and power. However, it is for missions requiring lifetimes greater than 20,000 hr and high electrical power levels that the fullest capabilities of electric propulsion spacecraft can be realized.

Absolute time scale of a development test program is dependent upon resources available and priorities assigned. Such a program must precede any mission launch date by at least five years. Presently, for instance, planetary missions for 1970 and 1971 are being defined, and final flight prototype design will be initiated within two years.

Strand, L.

AD48 LOW-PRESSURE COMBUSTION OF SOLID PROPELLANTS

Sehgal, R., Strand, L.

AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1524-1525

For abstract, see Entry AD43.

Trask, D. W.

AD49 RESULTS ON PHYSICAL CONSTANTS AND RELATED DATA FROM THE RADIO TRACKING OF MARINER (VENUS) AND RANGER III-VI MISSIONS

Sjogren, W. L., Trask, D. W.

For abstract, see Entry AD44.

Vickers, J. M.F.

AD50 THERMAL SCALE MODELING

Vickers, J. M. F.

Astronautics and Aeronautics, Vol. 3, May 1965, pp. 34-39

This article is a description of the test methods using scale models to predict the thermal behavior of spacecraft. Discussed are the (1) effects of mission and spacecraft considerations on modeling requirements, (2) modeling techniques and associated problems, (3) applications of spacecraft thermal modeling and (4) the current status of the technique.

AD51 THERMAL SCALE MODELING OF SPACECRAFT: AN EXPERIMENTAL INVESTIGATION

Fowle, A. A., Gabron, F., Vickers, J. M. F.

Journal of Spacecraft and Rockets, Vol. 3, No. 4, April 1966, pp. 557-581

For abstract, see Entry AD12.

Von Weyssenhoff, H.

AD52 VALIDITY AND LIMITATIONS OF THE GAS TITRATION OF ATOMIC NITROGEN WITH NITRIC OXIDE

Von Weyssenhoff, H., Patapoff, M.

The Journal of Physical Chemistry, Vol. 69, No. 5, May 1965, pp. 1756-1758

One of the standard methods for measuring the concentration of nitrogen atoms in active nitrogen is gas titration with nitric oxide. Two other techniques in which the atomic nitrogen was titrated with ethylene or molecular oxygen were found to yield consistent results which were considerably lower than the values given by the nitric oxide titration.

The nitric oxide titration may not be valid unless there is a sufficiently long time interval between the discharge and titration zone to permit deactivation of excited species.

Weetall, H. H.

AD53 PRECIPITATION OF SALMON SPERM DEOXYRIBONUCLEIC ACID WITH PURINE-SPECIFIC ANTIBODY

Weetall, H. H., Weliky, N.

Nature, Vol. 207, No. 4999, August 21, 1965, pp. 858-860

Deoxyribonucleic acids (DNA) have been found to react with antisera prepared by immunizing animals to Gram-negative bacteria, DNA, nucleosides, nucleotides, purines and pyrimidines. This was first demonstrated by complement fixation and then by precipitin reaction.

It has been found that samples of salmon sperm and *Clostridium* DNA, thermally denatured in the absence of formaldehyde, precipitated with anti-purinoyl antibody and showed only slight hyperchromicity after re-heating past the thermal transition temperature and cooling slowly, thus re-

sembling formaldehyde denatured calf thymus and chick embryo DNA in their immunochemical reactions. Comparison of the reported base composition of salmon sperm DNA with those of calf thymus and chick embryo DNA disclosed little difference.

Weliky, N.

**AD54 PRECIPITATION OF SALMON SPERM
DEOXYRIBONUCLEIC ACID WITH
PURINE-SPECIFIC ANTIBODY**

Weetall, H. H., Weliky, N.

Nature, Vol. 207, No. 4999, August 21, 1965, pp. 858-860

For abstract, see Entry AD53.

Wolfe, A. E.

AD55 RANGER VII, A NEW SPACE INSTRUMENT

Forney, R. G., Kindt, D. H., Kirhofer, W. E.,

Schurmeier, H. M., Wolfe, A. E.

Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13-35

For abstract, see Entry AD11.

Wrobel, J. R.

**AD56 SOME EFFECTS OF GAS STRATIFICATION ON
CHOKED NOZZLE FLOWS**

Wrobel, J. R.

Journal of Spacecraft and Rockets, Vol. 2, No. 6,
November-December 1965, pp. 918-922

The influence of the difference in properties of the constituents of a stratified multicomponent ideal gas on the flow through a nozzle is investigated analytically. The characteristic velocity c and the specific impulse I_s are computed and compared with values appropriate to the cases of thoroughly mixed gas constituents and equilibrium flow. These predictions are compared with the results of an approximate method using average properties, to illustrate the validity of the approximate method presented. The limited comparison indicates that the approximate method is virtually exact in predicting the c and I_s values appropriate to stratified flow, provided that the specific heat ratios of the constituent gases are nearly equal. The assumption of thoroughly mixed gases yields results that lie between the stratified-flow predictions and the equilibrium-flow predictions for the examples studied.

Younkin, R. L.

**AD57 SPECTRAL ENERGY DISTRIBUTIONS AND
REFLECTIVITIES OF MARTIAN MARIA AND
CONTINENTS IN THE VISIBLE AND
NEAR INFRARED**

Younkin, R. L.

The Astronomical Journal, Vol. 70, No. 9, November 1965,
Number 1334, pp. 666-698

(Abstracts of Papers presented at the 119th Meeting of the
American Astronomical Society, held August 3-6, 1965
at the University of Michigan, Ann Arbor)

Photoelectric measurements were carried out on 17 and 18 February 1965 to determine the ratio of the specific intensity of the Martian maria to that of the continents at a series of wavelengths from 5000 to 11 125 Å. The measurements were made with the Mt. Wilson 60-in. reflector and the Mt. Wilson Ebert spectrometer.

Syrtis Major was selected as the representative mare, and Aeria as the continent. The ratio of their intensities, corrected for normal incidence, increased monotonically from 1.25 at 5000 Å to 2.1 near 8000 Å. Beyond this wavelength it was very nearly constant.

The measurements on Syrtis Major and Aeria were also reduced independently to determine their relative spectral energy distributions and reflectivities. In the visible spectral region, 5000 to 7000 Å, the energy distribution of both areas increased sharply to the red, although that of Syrtis Major less than Aeria. The reflectivity of each area is very nearly constant at longer wavelengths. As λ decreases the two merge together in accordance with the results of previous observers who have found a complete obliteration of surface details by the atmosphere below 4200 Å.

The laboratory limonite absorption band near 8000 Å is totally lacking from the reflection spectrum of Aeria with an uncertainty of no more than 2%. It may be concluded the continents of Mars are not covered with pure limonite.

**AD58 FURTHER STUDIES OF THE INFRARED SPECTRA
OF COOL STARS, THE WATER DEFICIENCY IN
S STARS AND VARIATION OF WATER
ABUNDANCE WITH MIRA'S PHASE**

Spinrad, H., Pyper, D. M., Newburn, R. L., Jr.,
Younkin, R. L.

The Astrophysical Journal, Vol. 143, No. 2, February 1966,
pp. 291-298

For abstract, see Entry AD45.

**AD59 INFRARED BANDS OF VANADIUM OXIDE
IN THREE MIRA STARS**

Spinrad, H., Younkin, R. L.

Publications of the Astronomical Society of the Pacific,
Vol. 78, No. 460, February 1966, pp. 66-67

For abstract, see Entry AD46.

**AD60 VISIBLE AND NEAR-INFRARED
SPECTROPHOTOMETRY OF SATURN'S RINGS**

Younkin, R. L., Münch, G.

The Astronomical Journal, Vol. 71, No. 3, April 1966,
No. 1338, p. 188

Measurements of the narrow-band spectral energy distribution of the rings of Saturn have been made at the Mount Wilson Observatory using the 60-in. reflector and the Fastie-

Ebert spectrometer. Special scans from 0.51 to 1.1 μ were made of a segment of the rings at the western end of the semimajor axis.

The energy distribution was determined at 54 points in this wavelength region. The color sensitivity of the system was determined from scans of α Lyr and the α Lyr energy distribution of Oke. The relative reflectance of the rings was calculated by use of the solar intensity values of Labs and Neckel, converted to solar flux by the ratios of Minnaert.

The reflectance of the rings is very nearly constant from 0.78 to 1.05 μ . Shortward of this region it falls slowly to 0.60 μ , then more rapidly to a value at 0.51 μ some 0.45 below the maximum. There is a slight decrease in reflectance (0.03–0.05) from 1.05 to 1.08 μ . This is marginally outside of the experimental error. Owen has recently reported a drop in the reflectance of the rings from 1.04 to 1.09 μ , which he identified as due to water ice. This drop was determined on the basis of a drop in the ratio of the intensity of the rings to the intensity of Saturn in this region. Separate measurements at Mount Wilson of the reflectance of Saturn show a continuous strong absorption from 0.97 to 1.04 μ . This unfortunate coincidence yields a large drop in the ratio beyond 1.04 μ which will completely mask any possible ice absorption which by the results above will be only a few percent at most.

AD61 A SEARCH FOR LIMONITE NEAR-INFRARED SPECTRAL FEATURES ON MARS

Younkin, R. L.

The Astrophysical Journal, Vol. 144, No. 2,

May 1966, pp. 809–818

Previous authors have found limonite to be the only mineral whose polarization, color, and albedo duplicate those of the bright areas of Mars in the visual spectral region. Recent measurements of spectral reflectance show in the near-infrared that powdered limonite exhibits two characteristics, a wide-band absorption with minimum reflectance in the 8200–9500-Å region and, just beyond this absorption, a rise in reflectance.

Spectrophotometric measurements from 0.5 to 1.1 μ have been made at Mount Wilson of the integral intensity of the disk of Mars and of a bright area and a dark area. Comparison of the intensities of the two areas gives no indication of any difference in limonite content. The integral intensity has been reduced to relative reflectance by means of the energy distribution of α Lyr, and independently it has been compared directly to the intensity of the lunar crater Plato. An upper limit of 2% may be placed on the strength of the limonite spectral features in the reflectance of Mars.

Numerical Index

Technical Reports

Technical Report	Entry No.	Technical Report	Entry No.	Technical Report	Entry No.
32-77, Part II	C10	32-772	A08	32-832	C18
32-255, Part I	R35	32-774	W01	32-833	A06
32-255, Part VI	C13	32-775	W18	32-835	K07
32-293	L23	32-776, Part I	R35	32-836	H21
32-400	L16	32-776, Part II	B17	32-837	K03
32-503, Rev. 1	R12	32-776, Part III	E11	32-838	G02
32-532, Part I	F06	32-777	W04	32-839	T07
32-563	S16	32-779	T01	32-840	C19
32-583	C12	32-780	W27	32-841	J04
32-601	M17	32-781	K10	32-842	K22
32-616	W17	32-782, Part I	J05	32-843	J11
32-633	L02	32-782, Part II	P04	32-844	A02
32-665	S19	32-783	F02	32-845	F04
32-666	R20	32-784	M18	32-847	C17
32-671	C06	32-785	L17	32-848	P11
32-675	S02	32-786	R21	32-849	M26
32-689	J08	32-787	L15	32-851	L18
32-698	B24	32-788	C14	32-853	D08
32-710	H18	32-789	R24	32-854	B29
32-711	A11	32-791	R09	32-856	J01
32-712	H16	32-792	G14	32-857	M04
32-713	B14	32-793	G04	32-859	W14
32-722	J12	32-794	B16	32-860	L12
32-725	M30	32-796	K06	32-861	K21
32-727	C08	32-797	Z01	32-862	B08
32-728	B01	32-799	G06	32-863	K16
32-731	A09	32-800, Part I	J07	32-864	P07
32-735	D05	32-800, Part II	H12	32-865	K05
32-738	K11	32-802	W05	32-866	F08
32-739	L14	32-803	D01	32-867	B02
32-740, Vol. I	J06	32-805	W26	32-868	W02
32-741	S09	32-806	H06	32-869	A10
32-746	M05	32-807	M12	32-870	K12
32-749	D07	32-808	P06	32-871	P02
32-750	R34	32-810	L24	32-872	W08
32-751	R38	32-811	L13	32-873	E02
32-752	T14	32-812	W22	32-874	H05
32-753, Part II	T15	32-814	M01	32-875	M02
32-754	G13	32-815	S21	32-876	S04
32-755	E04	32-817	G15	32-877	N04
32-756	S23	32-818	T04	32-878	P15
32-757	J03	32-819, Vol. I	T02	32-879	W09
32-758	W03	32-820	B25	32-880	I02
32-759	W32	32-821, Part II	W33	32-885	G12
32-760	J10	32-822	B05	32-887	S28
32-761	H02	32-823	B10	32-889	K23
32-762	K19	32-824	M31	32-890	A02
32-763	H08	32-825	E01	32-892	R22
32-764	E12	32-826	T16	32-894	S15
32-765	R08	32-827	T05	32-896	J02
32-770	T10	32-828	K14	32-898	B19
32-771	C15	32-829	E09	32-900	C03
		32-830	S05	32-901	S29

Technical Report	Entry No.	Technical Report	Entry No.	Technical Report	Entry No.
32-902	T06	32-911	M24	32-930, Part I	M10
32-903	C16	32-913	M20	32-934	C09
32-904	I03	32-914	P09	32-937	S20
32-905	K13	32-917	D10	32-938	G05
32-906	D03	32-918	B21	32-941	K02
32-907	O01	32-923	S12	32-944	K18
32-908	C02	32-925	L07	32-945	J09
32-909	W23	32-927	K08	32-962	K20
32-910	T12	32-928	H10	32-967	W07

Technical Memorandums

Technical Memorandum	Entry No.	Technical Memorandum	Entry No.	Technical Memorandum	Entry No.
33-100, Vol. IV, Part A	R13	33-220	L05	33-254	H13
33-100, Vol. IV, Part B	R14	33-221	S11	33-256	T13
33-100, Vol. IV, Part C	R15	33-222	S18	33-260	F11
33-100, Vol. IV, Part D	R16	33-228	B04	33-261	B07
33-100, Vol. V, Part A	R17	33-230	L19	33-262, Vol. I	D02
33-100, Vol. V, Part B	R18	33-231	M13	33-263	G09
33-100, Vol. V, Part C	R19	33-232	D04	33-264	S30
33-135	A04	33-234	S26	33-266	C01
33-136	A05	33-236	C04	33-267	F05
33-196	B30	33-237	T11	33-270	H19
33-197	S22	33-238	I05	33-271	H11
33-212	R10	33-239	R11	33-273	M25
33-216	B06	33-241	S25	33-274	S13
33-217	C07	33-242	B09	33-278	R02
33-218	H14	33-244	H20	33-282	B27
		33-251	K01	33-288	H17

Space Programs Summary

Space Programs Summary	Entry No.	Space Programs Summary	Entry No.	Space Programs Summary	Entry No.
37-33, Vol. IV	AB04	37-35, Vol. V	AB05	37-37, Vol. IV	AB04
37-34, Vol. I	AB01	37-35, Vol. VI	AB06	37-37, Vol. VI	AB06
37-34, Vol. II	AB02	37-36, Vol. I	AB01	37-38, Vol. I	AB01
37-34, Vol. III	AB03	37-36, Vol. II	AB02	37-38, Vol. II	AB02
37-34, Vol. IV	AB04	37-36, Vol. III	AB03	37-38, Vol. III	AB03
37-34, Vol. V	AB05	37-36, Vol. IV	AB04	37-38, Vol. IV	AB04
37-34, Vol. VI	AB06	37-36, Vol. V	AB05	37-38, Vol. V	AB05
37-35, Vol. I	AB01	37-36, Vol. VI	AB06	37-38, Vol. VI	AB06
37-35, Vol. II	AB02	37-37, Vol. I	AB01	37-39, Vol. I	AB01
37-35, Vol. III	AB03	37-37, Vol. II	AB02	37-39, Vol. II	AB02
37-35, Vol. IV	AB04	37-37, Vol. III	AB03	37-39, Vol. VI	AB06

Astronautics Information Literature Search

Literature Search	Entry No.
541	AC01

Subject Index

Subject	Entry	Subject	Entry	Subject	Entry
Aerodynamics		Boundary Layer		Chemistry (Cont'd)	
(see also Atmospheric Entry , Wind Tunnels)		laminar, from partially-ionized		controlled thermal degradation	
translational and rotational motion		monatomic gasB02		of mesoporphyrinW22	
of body entering Mars		effect of transition on dynamic			
atmosphereF04		stabilityJ04		Clean Rooms	
pressure telemeter for wind tunnel				experimental assembly and	
free-flight measurementsH08		Carbon Dioxide		sterilization laboratory,	
dynamic-stability flight analysis,		diffusion rates determined on closed-		descriptionK02	
generalized approachJ03		cell polyurethane foamC19			
free-flight dynamic stability, effect		parallel bands, spectral		Coatings	
of boundary layer transitionJ04		emissivity calculationsG13		reflectances and transmittances	
free-body motions of spacecraft,		relative intensity calculationsG15		of painted aluminum and	
methods of analysisL12				paint filmsE02	
prediction method of flight		Chemistry			
acceleration at base of booster....T11		4-dicarbaheptaborane (7),		Coding	
spacecraft, interactions with		microwave spectrum, structure,		pseudo-random, technique of	
natural plasmasAC01		dipole momentB10		ranking as applied in	
		nitrogen analogs of sesqui-		Mark 1 subsystemL13	
Antennas		fulvalene, Part II ground-state		coded noncoherent	
large apertures and arrays for deep		propertiesB17		communicationsL14	
space communicationsP11		immunoadsorbents, cellulose			
		derivatives preparationC03		Combustion	
Atlas-Centaur		ozone photolysis, primary		rotating detonation-like wave	
IV, flight path and its determina-		processesD03		observed during resonant mode...C14	
tion from tracking data.....M24		application of Ross filters for non-		effects on mixing of highly	
		dispersive analysis of Al and Si...D10		reactive liquid propellantsJ08	
Atmospheric Entry		induced absorption of solutions of		effects and nonreactive properties	
translational and rotational motion		H ₂ and D ₂ in liquid neonE12		of injection schemesR35	
of body entering Mars		chromatographic separation of			
atmosphereF04		hydrogen isotopes, electro-		Communications	
injectant materials to alleviate Mars		static theoryK12		(see also Antennas , Coding , Receivers , Telecommunications)	
entry communication blackout....K07		chloride alkoxides of		systems comparison of data	
		pentavalent tungstenK16		return modes for advanced	
Bibliography		synthesis of carbon-14 labeled		missionsB04	
spacecraft, interactions with		isocyanatesK21		between ground station and	
natural plasmasAC01		glassy carbon, tensile and		satellites, geometric aspects.....B25	
		structural propertiesK22		injectant materials to alleviate	
Biology		rates of some degenerate		Mars entry communication	
(see also Exobiology)		rearrangements determined by		blackoutK07	
sampling and handling of desert		NMR spectroscopyM04		unambiguous accuracy of	
soils, techniquesC02		NMR proton-proton coupling		interferometer angle-measuring	
immunoadsorbents, cellulose		constants in styrene sulfide		systemK10	
derivatives preparationC03		and styrenimineM05		coded noncoherent	
immunoadsorbent for isolation of		alcohols classified from 19F		communicationsL14	
purine-specific antibodiesW03		spectra of trifluoroacetatesM10		optimum coherent linear	
micro-organisms in soils, detection		equilibria between metallic sodium		demodulationL15	
by their catalytic activity.....W04		and aromatic hydrocarbonsR08		large antenna apertures and	
coupling of biologically active		sodium chloride crystals, effect		arrays for deep space.....P11	
molecules to insoluble		of predeformation on		variance of spectral estimatesR22	
polymersW05		mechanical propertiesS12		dc-potentiometer microwave	
enzymatic detection of hydrogen		fluoroform, thermal decomposition		insertion-loss test setS28	
peroxide, new technique cellulose		in single-pulse shock tube.....T15			
derivatives for study of biological		thermal decomposition of		Computer Programs	
systemsW14		hexafluoroethane in presence		adaptive numerical integration	
		of hydrogenT16		routine for IBM 1620 II.....K20	
		enzymic detection of hydrogen		for structural analysis, functions	
		peroxide, new techniqueW07		and capabilitiesL05	
				spacecraft visibility program with	
				contour plotterM25	

Subject	Entry	Subject	Entry	Subject	Entry
Computer Programs (Cont'd)		Exobiology		Guidance and Control	
constraints-restraints analog		gas chromatography-mass		magnetic control of spacecraft,	
plotter program	S18	spectrometry techniques		proceedings of workshop	B06
to solve structural problems	W01	for detection	B14	injection accuracy characteristics	
Cryogenics				for lunar missions	T07
Philips cycle for low-temperature		Fluid Dynamics		Heat Transfer	
refrigeration	H16	experimental methods in rarefied		and shear stress predictions from	
Data Processing		gas dynamics	A10	existing similarity solutions	B01
quantile system of data com-		BCK equation, numerical con-		laminar boundary-layer, from	
pression for space telemetry	A08	vergence of iterative solution	C06	partially-ionized monatomic gas	B02
use of quantiles in data com-		estimation of strength of lip shock	H05	thermal conductivity of noble	
pression of space telemetry	E04	slow motion of sphere in		gases in 1500 to 5000 deg K	
SFOF document control storage		rotating viscous fluid	M17	range, measurement	C16
and retrieval system	H17	sphere drag at low Reynolds			
digital video-data handling, tech-		numbers, accurate			
nique for accurate analysis	N04	measurements	M18		
Deep Space Instrumentation Facility		shock-wave density profiles,		Impact Studies	
analysis of tracking performance		electron-beam measurements	R38	JPL program, status of	
during <i>Mariner II</i> flight	C08			investigations and testing	A02
characteristics and format data		Fluid Flow		balsa wood as energy dissipator,	
obtained for lunar orbiter	L19	localized-induction concept on		environmental and physical	
support of <i>Mariner II</i> mission,		a curved vortex	A09	effects	K18
performance evaluation	R10	laminar boundary-layer, from		Instrumentation	
Earth		partially-ionized monatomic		890 MHz noise-measuring	
phase-change hypothesis of		gas	B02	equipment, description and	
structure	L24	thermal conductivity of noble		analysis	B19
Elastomers		gases in 1500 to 5000 deg K		motor-driven mechanisms for	
effects of statistical variability		range, measurement	C16	spaceflight applications	F08
and crosslink density	L02	interference phenomena between		pressure telemeter for wind-tunnel	
tensile failure envelope of		three jet plumes	M13	free-flight measurements	H08
amorphous systems	L02	sub-alfvénic flow in duct with		lunar and planetary X-ray	
Electrical Propulsion Systems		nonuniform magnetic field	P02	diffraction program	H14
plasma nonuniformity and grid		concentration ratio distributions		Mark 1 diffractometer, power	
erosion in electron bombard-		in binary compressible vortex		supply and electronic systems	H14
ment engine	K11	flow	P06	<i>Mariner II</i> microwave radiometer	
Electronic Components		confined binary vortex flow		experiment	J12
photon-actuated multiplex		fields, measurement	P07	measurement devices applicable	
switch development	B16	similarity in confined vortex flows	R24	to solar simulation systems	L07
890-MHz noise measuring		reaction dwell time and cooling		lunar and planetary petrography	
equipment, description		rate in shock tube	T14	experiment	L17
and analysis	B19			calibration methods used on	
noise suppression in quasi-		Fuel Cells		<i>Mariner</i> Canopus sensor	M20
balanced circuits, filtering		(see Power Supplies)		ruggedized thin-window	
techniques	J09			proportional-counter tube	S11
Environmental Testing		Gas Chromatography		lunar X-ray diffraction	
power spectral density analysis	H10	for detection of life-related com-		experiment, development	S23
solar, potential application of		pounds on planetary surfaces	B14	dc-potentiometer microwave	
measurement devices	L07	electrostatic theory of		insertion-loss test set	S28
dynamic-stability testing		physical adsorption	K13		
techniques	P15	microsystem, components and		Jupiter	
Ephemerides		development techniques	W25	Caltech-JPL lunar and planetary	
of Earth-Moon barycenter,		Geology		conference	C01
Venus, Mars, and Mercury	D04	sampling and handling of desert		computed data for trajectories to	C10
		soils, techniques	C02		
		problems of Mars	L16	Landing Structures	
		phase-change hypothesis of		Mars entry and landing capsule,	
		structure of Earth	L24	feasibility and complexity	C04
				balsa wood as energy dissipator,	
				environmental and physical	
				effects	K18

Subject	Entry	Subject	Entry	Subject	Entry
Landing Structures (Cont'd)		Magnetic Fields		Mars (Cont'd)	
Martian atmospheric and surface models, for capsule-lander study	S26	force on superconducting sphere in nonuniform field	H06	Caltech-JPL lunar and planetary conference	C01
Launching		high-frequency conductivity of plasma in quasi-equilibrium	W33	entry and landing capsule, feasibility and complexity	C04
electrostatic charging and discharging models and analysis . . .	C15	Magnetics		high-energy trajectories from Earth to Mars and return	D01
injection accuracy characteristics for lunar missions	T07	magnetic control of spacecraft, proceedings of workshop	B06	translational and rotational motion of body entering atmosphere	F04
Liquid Propellants		Magnetohydrodynamics		power systems related to operation of landing capsule	I05
Earth-storable, research and advanced development program	D05	electron density and temperature measurements in exhaust of MPD source	K06	injectant materials to alleviate entry communications blackout . . .	K07
highly reactive, effects of combustion on mixing	J08	Mariner Project		geologic problems	L16
Liquid Propulsion Systems		IV, photography of Mars, initial results	A02	Earth-Mars trajectories	R13
problems of chemical compatibility, permeation and folding of bladders	B08	IV, measurements near Mars, initial results	A06	models of atmosphere and surface for capsule-lander studies	S26
large expulsion bladders for nitrogen tetroxide and hydrazine	B08	magnetic contamination status report	B07	micro-gas chromatographic system to analyze atmosphere . . .	W26
midcourse system for <i>Ranger</i> Block III	E09	scientific objectives and experiments for Venus mission . . .	B27	Masers	
ALPS generant tank and cell assembly	K05	II, electrochemical energy source, development	B29	two-cavity, for planetary radar	C12
<i>Surveyor</i> vernier plume/RADVS-system, interactions effects	K08	II, flight, DSIF tracking performance	C08	proposed gas maser pumping scheme for far infrared	W17
ALPS generant controller development	M01	IV, scan platform and actuator, development and performance . .	C18	Materials	
fill valve development for ALPS . . .	M02	Mars 1964, telecommunications systems performance during mission	H21	(see also Coatings, Tungsten)	
concentration ratio distributions in binary compressible vortex flow	P06	IV mission, Part I—pre-encounter data	J05	application of Ross filters for non-dispersion analysis of Al and Si	D10
teflon propellant expulsion bladders, fabrication	P09	Mars 1964, project report, inception through midcourse maneuver	J06	graphitization transformation in pyrolytic carbons	F06
thrust-chamber erosion, effect of injector design	R34	II, microwave radiometer experiment	J12	injectant materials to alleviate Mars entry communication blackout	K07
post-injection system for <i>Mariner C</i>	S05	IV, calibration methods used on Canopus sensor	M20	balsa wood as energy dissipator, environmental and physical effects	K18
Lunar Probes		IV, mission to Mars, post-encounter data	P04	glassy carbon, tensile and structural properties	K22
unmanned, utility and requirements evaluation	S25	Mars 1964, analysis of dynamic flight environment	R02	pyrolytic carbon, analysis of high temperature creep	K23
Lunar Surface		III and IV, dynamic flight environment data compared	R02	teflon propellant expulsion bladders, fabrication	P09
large-scale photogrammetry, new techniques and procedures	B21	II, DSIF support, performance evaluation	R10	salt crystals; growth, deformation, and defect structure	S13
evidence of darkened layer from <i>Ranger VII</i> photographs	F05	IV, near-Earth trajectory phase, tracking and data acquisition . . .	R11	optical, determination of refractive indices	S15
depth and bearing strength of dust . .	J01	C, post-injection propulsion system	S05	nonconducting ceramics, mass spectrographic analysis	S21
comparison of laboratory craters and <i>Ranger VII</i> photographs	J02	Mars		thermoelectric power in niobium-zirconium alloys	W08
lunar and planetary petrography experiment	L17	<i>Mariner IV</i> photographs, initial results	A02	phonon-drag thermopower in dilute copper alloys	W09
photometric method for deriving topographic information	R21	systems comparison of data return modes for advanced missions	B04	Mathematics	
lunar X-ray diffraction experiment, development	S23			effectiveness of fault-detecting codes	A11
				mathematical equation for electrodynamic vibration system	C09

Subject	Entry
Mathematics (Cont'd)	
Hadamard matrices of order 20	H02
stiffness matrix structural analysis	W01
Mercury	
computed data for trajectories to	C10
Meteorites	
reduction of lunar distance through meteoritic impacts	L23
effect on lunar orbit of meteoritic accretion	L23
polymineralic inclusions in Odessa	M12
Moon	
(see also Lunar Probes, Lunar Surface)	
Caltech-JPL lunar and planetary conference	C01
observational investigation of brightness temperature at 3.3 mm	G02
analysis of <i>Rangers VIII</i> and <i>IX</i> photographs	H12
effect on lunar orbit of meteoritic accretion	L23
reduction of lunar distance through meteoritic impacts	L23
review of photographic mission and discussion of results	S20
Multiplexing Systems	
analysis methods under partial-success criteria	B24
reliable time multiplexing by replacement	K14
Nuclear Fuels	
in-pile thermionic space reactors, Vol. I	D02
gaseous-fuel-retention devices, evaluation	P07
Nuclear Magnetic Resonance	
NMR spectra of poly(alkylene oxide) terminal groups	I03
rates of some degenerate rearrangements, determination	M04
proton-proton coupling constants in styrene sulfide and styrenimine	M05
for characterization of functional groups	M10
alcohols classified from 19F spectra of trifluoroacetates	M10
Orbits	
design parameters for ballistic interplanetary trajectories	C10

Subject	Entry
Orbits (Cont'd)	
high-energy trajectories from Earth to Mars and return	D01
least square fit to plod rectangular residuals	H20
long term motion of satellite perturbed by third body	L18
effect on lunar orbit of meteoritic accretion	L23
determination of <i>Atlas-Centaur IV</i> flight path	M24
utilizing large planetary perturbations to obtain trajectories	M26
Earth-Moon trajectories, 1960-70	R12
Earth-Mars trajectories	R13
<i>Ranger III</i> flight path determined from tracking data	S16
Perturbation Theory	
long term motion of satellite perturbed by third body	L18
utilizing large planetary perturbations to obtain trajectories	M26
Photogrammetry	
large-scale lunar, new techniques and procedures	B21
Photography	
figure of merit measuring picture resolution	R20
Photometry	
for deriving lunar topographic information	R21
Physics	
nitrogen analogs of sesquifulvalene, Part II ground-state properties	B17
ozone photolysis, primary processes	D03
many-electron-theory <i>ab initio</i> calculation for Be Atom	G06
single-crystal barium titanate, linear electro-optic effect	J10
single-crystal barium titanate, strain-free electro-optic effect	J11
chromatographic separation of hydrogen isotopes, electrostatic theory	K12
slow motion of sphere in rotating viscous fluid	M17
near-ultraviolet bands of MgO, analysis	T10
rigid motions in Einstein spaces	W02
proposed gas maser pumping scheme for far infrared	W17
theory of particle symmetries	Z01

Subject	Entry
Planetary Atmospheres	
(see also Atmospheric Entry)	
use of wind tunnels to simulate aerodynamics	K19
models of Mars, for capsule-lander studies	S26
nonequilibrium and equilibrium radiation, measurements	T06
Mars, analysis by micro-gas chromatographic system	W26
Planetary Missions	
systems comparison of data return modes for advanced missions	B04
Mars entry and landing capsule, feasibility and complexity	C04
Planets	
(see also Specific Planets)	
ultraviolet spectrum, description of physical process	B05
least square fit to plod rectangular residuals	H20
utilizing large planetary perturbations to obtain trajectories	M26
Plasma	
(see also Fluid Dynamics, Magnetohydrodynamics)	
fully ionized, temperature relaxation time	W13
high-frequency conductivity of, in quasi-equilibrium	W33
interactions with spacecraft and other moving bodies, bibliography	AC01
Polymers	
(see also Elastomers)	
molecular weight determination by light scattering	B09
outgassing rates in polymeric foams	C19
SBR gum vulcanizates, variability of ultimate properties	F02
thermal degradative processes in polyether-polyurethans	I02
NMR spectra of poly(alkylene oxide) terminal groups	I03
molecular structure and configuration	I03
end-group modification of poly(alkylene oxides) Vol. I, cyanoethylation	K01
preparation of polytriphenylene, organic synthesis using fused salt	O01
electron transfer to vinylaromatic polymers	R09
coupling of biologically active molecules in insoluble polymers	W05

Subject	Entry	Subject	Entry	Subject	Entry
Power Supplies		Ranger Project (Cont'd)		Rocket Motors (Cont'd)	
development of electrochemical battery for <i>Mariner II</i>B29		Block III, midcourse propulsion systemE09		thrust-chamber erosion, effect of injector designR34	
in-pile thermionic space reactors, Vol. ID02		evidence of darkened lunar surface layer from photographsF05		application of nonreactive-spray properties to injection designR35	
development of point damper for <i>Ranger</i> solar panelsG04		point damper for solar panels, developmentG04		Shock Tubes	
variables influencing erosion in wet-vapor turbinesH11		VIII and IX experimenter's analysis and interpretation, Part IIH12		pyrotechnic shock analysis and testing methodsH19	
proposed for Mars landing capsulesI05		VII photographs, compared to laboratory cratersJ02		nonequilibrium and equilibrium radiation, measurementsT06	
fission-electric cell reactor, design studyS09		VIII and IX, mission description and performanceJ07		single-pulse, reaction dwell time and cooling rateT14	
Propellants		III, flight path determination from tracking data photometric calibrationS19		thermal decomposition of hexafluoro- ethane in presence of hydrogen...T16	
(see also Liquid Propellants , Solid Propellants , and Nuclear Fuels)		review of photographic mission and discussion of resultsS20		Shock Waves	
ability to withstand sterilization temperature cyclingG09		use of flight data for <i>Surveyor</i> vibra- tion qualification testingT11		BGK equation, numerical conver- gence of iterative solutionC06	
Propulsion Systems		ground test acoustic simulations applied to flight dataT12		density profiles, electron-beam measurementsR38	
(see Electrical Propulsion Systems , Liquid Propulsion Systems , and Rocket Motors)		simulation of lift-off and transonic vibration excitation mechanisms...T13		Simulators	
Quantum Mechanics		dynamic environment during launch portionW24		25-ft, evaluation of simulated solar spectrumD07	
particle symmetries theory based on general principleZ01		Reactors		25-ft, comments on operationG12	
Radar Astronomy		in-pile thermionic space reactors, Vol. ID02		solar, potential application of measurement devicesL07	
review of development and descrip- tion of new measuring techniquesM31		gaseous-fuel-retention devices, evaluationP07		description of JPL facilitiesS22	
Radar Echoes		Receivers		space molecular sink simulator facility, design and developmentS29	
high-altitude rocket radar project...B30		dc-potentiometer microwave insertion-loss test setS28		Solar Cells	
Radar Systems		phase-locked, theory and practical design, Vol. IT02		(see Power Supplies)	
high-altitude rocket radar project...B30		Relativity Theory		Solid Propellants	
planetary, two cavity maserC12		rigid motions in Einstein spaces...W02		JPL-533, properties and performanceA04	
<i>Surveyor</i> vernier plume/RADVS— system interactions effectsK08		particle symmetries theory based on general principle ofZ01		JPL-534, properties and performanceA05	
technique of range determination with pseudo-random codesL13		Reliability		for space exploration, reviewH13	
closed-loop range-lockedT01		two-sided tolerance factors for normal distributions, tablesC07		multiaxial data, characterized by con- tinuous media theory approach...S02	
Radiation		Rocket Motors		Space Flight Operations Facility	
nonequilibrium and equilibrium, measurements using shock tubesT06		starting-flow-transient criteria for gas-pressurized liquid- bipropellantC13		document control data storage and retrieval systemH17	
near-ultraviolet bands of MgO, analysisT10		liquid, rotating detonation-like wave during resonant combustionC14		Spacecraft	
Ranger Project		solid-propellant batch-check motor, evaluationF11		magnetic control of spacecraft, pro- ceedings of workshopB06	
890-MHz noise-measuring equip- ment, description and analysis...B19		ALPS generant tank and cell assemblyK05		sterilization program, statusD08	
electrostatic charging and discharg- ing models and analysisC15		solid-propellant, sterilized for Mars landing missionsM30		dynamic testing of, boundary- condition simulationG05	
vibration testing, advantages of multipoint controlC17				free-body motions of spacecraft, methods of analysisL12	
				shock and vibration environment im- posed on, during transportation...S04	
				interaction with natural plasmas, bibliographyAC01	

Subject	Entry	Subject	Entry	Subject	Entry
Spectral Absorption		Superconductors		Tracking (Cont'd)	
of 4.6- μ bands of N_2OG14		force on a sphere in arbitrary		<i>Mariner IV</i> near-Earth trajectory	
Spectral Analysis		magnetic fieldH06		phase, tracking and data	
power spectral density analysisH10		transition of a rotating, the hollow		acquisitionR11	
variance of spectral estimatesR22		cylinderH18		precision planetary radar system,	
Spectrometry				descriptionT01	
for detection of life-related com-		Surveyor Project		Trajectories	
pounds on planetary surfacesB14		vernier plume/RADVS—system		(see <i>Orbits</i>)	
Spectroscopy		interactions effectsK08		Tungsten	
ultraviolet, of planetsB05		reverse flow in triangular central		slip at high temperaturesT04	
rates of some degenerate rearrange-		region of vernier motorsM13		single-crystal and polycrystalline,	
ments, determinationM04		mission operation system,		tensile behaviorT05	
nonconducting ceramics, mass		descriptionS30			
spectrographic analysisS21		vibration qualification testing, use		Venus	
Statistical Analysis		of <i>Ranger</i> flight dataT11		review of current knowledge and	
quantile system of data compression		Telecommunications		future science objectivesB27	
for space telemetryA08		quantile system of data compression		Caltech-JPL lunar and planetary	
two-sided tolerance factors for		for space telemetryA08		conferenceC01	
normal distributions, tablesC07		S-band, effect of interplanetary		<i>Mariner II</i> microwave radiometer	
use of quantiles in data compression		mediumE01		experimentJ12	
of space telemetryE04		use of quantiles in data compression		Vibration Testing	
figure of merit measuring picture		of space telemetryE04		mathematical equation for electro-	
resolutionR20		description of <i>Mariner</i> Mars 1964		dynamic vibration systemC09	
Sterilization		systems performanceH21		of complete <i>Ranger</i> spacecraft,	
JPL technology program, statusD08		Television Systems		multipoint controlC17	
of pyrotechnics and on-board		digital video-data handling, tech-		of spacecraft structure, boundary-	
propulsion systemsG09		nique for accurate analysisN04		condition simulationG05	
experimental assembly and steriliza-		<i>Ranger</i> photometric calibrationS19		ground test acoustic simulations	
tion laboratory, descriptionK02		Test Facilities		applied to flight dataT12	
of solid rocket motors for Mars		(see also <i>Shock Tubes, Simulators,</i>		simulation of <i>Ranger</i> launch and	
landing missionsM30		<i>Wind Tunnels</i>)		transonic excitation modesT13	
Structures		pyrotechnic shock analysis and		Wind Tunnels	
dynamic testing of, boundary-		testing methodsH19		(see also <i>Test Facilities</i>)	
condition simulationG05		free-flight telemetry testing in		low density, structure and utilization	
stress measurements on Blair High		wind tunnelW18		of supersonic free jetsA10	
School gymnasiumK03		Thermal Tests		pressure telemeter for wind-tunnel	
analysis system computer program,		pyrolytic carbon, analysis of high		free-flight measurementsH08	
functions and capabilitiesL05		temperature creepK23		to simulate planetary atmospheric	
stiffness matrix structural		Tracking		aerodynamicsK19	
analysisW01		evaluation of proposed antennas		dynamic-stability testing	
finite shear strain in shallow		and stations by visibility contour		techniquesP15	
spherical shell, evaluationW27		plotsM25		technique for obtaining interference-	
				free base pressure dataW18	